GEORGIA INSTITUTE OF TECHNOLOGY | OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[XX] ORIGINAL [ ] REVISION NO. ______

Project No. A-4050 GTRI/~~GIT~~ DATE 1 / 8 /85

Project Director: J. A. Bruder ~~School~~/Lab RAIL

Sponsor: Massachusetts Institute of Technology
Lincoln Laboratory

Type Agreement: Purchase Order CX-6211 (Under Gov't Prime F19628-85-C-0002)

Award Period: From 11/20/84 To ~~12/31/84~~* 2-15-85 (Performance) 12/31/84 (Reports)

Sponsor Amount:

	This Change	Total to Date
Estimated:	$ 40,027	$ 40,027
Funded:	$ 40,027	$ 40,027

Cost Sharing Amount: $ None Cost Sharing No: N/A

Title: MMWave Radar Study

ADMINISTRATIVE DATA OCA Contact Brian J. Lindberg X4820

1) Sponsor Technical Contact:

Director
MIT-Lincoln Laboratory
P. O. Box 73
244 Wood Street
Lexington, Massachusetts 02173-0073

2) Sponsor Admin/Contractual Matters:

Nancy J. Alusow
Associate Purchasing Manager
MIT-Lincoln Laboratory
P. O. Box 73
244 Wood Street
Lexington, Massachusetts 02173-0073

Defense Priority Rating: DO-A7

Military Security Classification: N/A
(or) Company/Industrial Proprietary: N/A

RESTRICTIONS

See Attached N/A Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed or anticipated

COMMENTS:

*Note: No cost extension through 2/15/85 has been requested.

JAN 1985 RECEIVED Research Reports Office

COPIES TO:

Project Director	Procurement/EES Supply Services	GTRI
Research Administrative Network	Research Security Services	Library
Research Property Management	Reports Coordinator (OCA)	Project File
Accounting	Research Communications (2)	Other ______

FORM OCA 4:383

SR5192-N-B

GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 8/2/85

Project No. A-4050

XXXXXX/Lab RAIL

Includes Subproject No.(s)

Project Director(s) J. A. Bruder

XXXX / GIT

Sponsor Massachusetts Institute of Technology, Lincoln Laboratory

Title MMWave Radar Study

Effective Completion Date: 2/15/85 (Performance) 2/15/85 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [X] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [X] Final Report of Inventions
- [X] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No.

Continued by Project No.

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/GTRI Supply Services
Research Security Services
Reports Coordinator (OCA)
Legal Services

Library
GTRC
Research Communications (2)
Project File
Other Heyser
Jones

FORM OCA 69.285

BRIEFING MATERIAL

presented at

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Boston, Massachusetts

October 18, 1984

by

N. C. Currie
W. A. Holm
D. L. Odom
J. A. Scheer
R. N. Trebits

GEORGIA TECH RESEARCH INSTITUTE
GEORGIA INSTITUTE OF TECHNOLOGY
Atlanta, Georgia

BRIEFING OUTLINE

EXECUTIVE SUMMARY

RADAR SYSTEM DESIGN CONSIDERATIONS

RF/IF HARDWARE REALIZATION

DATA ACQUISITION & SYSTEM CONTROL(AIRBORNE)

DATA PROCESSING, GROUND BASED

MEASUREMENT & CALIBRATION

PROGRAM ASPECTS

MIT/LL - DARPA
INSTRUMENTATION SAR PROGRAM

GTRI HAS DEVELOPED A STRAIGHTFORWARD, LOW RISK, COMPLIANT PROGRAM IN RESPONSE TO MIT/LL - DARPA NEED FOR AN AIRBORNE INSTRUMENTATION SAR DATA COLLECTION SYSTEM.

EXPERIENCE BASE

TEST AND INSTRUMENTATION	EXTENSIVE EXPERIENCE (>25 RECENT PROGRAMS)
AIRBORNE	VARIOUS PROGRAMS USING GTRI AND CONTRACTOR AIRCRAFT
POLARIZATION	RECOGNIZED AUTHORITY IN POLARIZATION RELATED PROCESSING
MILLIMETER WAVE	30 YEARS EXPERIENCE IN MILLIMETER WAVE R&D
HIGH RESOLUTION PROCESSING	PROVEN HIGH RANGE RESOLUTION TECHNIQUES
	STRAIGHT FORWARD, LOW RISK SAR APPROACH
	ALL AIRBORNE DATA RECORDED (NO PRE PROCESSING)
	GTRI STAFF AUGMENTED

TEST ENVIRONMENT

RANGE:	SHORT(1500M)
RANGE SWATH:	SMALL(150M)
PROCESSING:	NON. REAL TIME POLAR PROCESSING NOT REQ'D
FLIGHT ENVIRONMENT:	BENIGN, STRAIGHT & LEVEL
SYNTHETIC ARRAY TIME:	SHORT $T = \frac{R\lambda}{2\ell V}$ ($\cong$0.25sec)
UNCOMPENSATED ACCELERATION ALLOWABLE:	LARGE $a < \frac{\ell^2 V^2}{R^2 \lambda}$ ($\cong$0.04M/sec^2)

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

OUTLINE OF APPROACH

PULSED Ka - BAND RADAR:

- 70 WATT TWTA
- CHIRPED/COMPRESSED PULSE
- STEPPED FREQUENCY FOR ULTIMATE RANGE RESOLUTION
- POLARIZATION DIVERSE ON TRANSMIT } FULL POLARIZATION MATRIX
- DUAL POLARIZED ON RECEIVE } FULL POLARIZATION MATRIX

SAR - STRIPMAP, SPOTLIGHT

- ZERO DOPPLER PROCESSING
- RECORD RADAR, NAV, MOCOMP DATA ON TAPE
- DATA PROCESSING VAN FOR
  - QUICK-LOOK PROCESSING
  - PRODUCTION PROCESSING

RAR -

- FORWARD LOOKING, SCANNING REAL BEAM

GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SYSTEM ENHANCING FEATURES

IMPROVED CROSSPOLARIZATION ISOLATION:	NOT ACHIEVABLE W/O PENCIL(CIRCULAR)BEAM WHICH COMPROMISES PERFORMANCE
3 - AXIS POSITIONER:	COST -
INCREASED RANGE SWATH:	HIGHER AVERAGE DATA RATE DRIVES RECORDER COST
INCREASED CROSSRANGE SWATH:	NO EFFECT IN STRIPMAP LARGER QUANTUM ANGULAR STEPS IN SPOTLIGHT
REDUCED CROSSRANGE RESOLUTION (DBS):	NOT ADVISED

RADAR SYSTEM DESIGN CONSIDERATIONS

1. RANGE RESOLUTION APPROACH

2. SAR

   - ISSUES
   - STRIP MAP MODE
   - SPOTLIGHT MODE

3. RAR

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RANGE RESOLUTION ISSUES

TECHNIQUE	COMMENTS
1. REAL PULSE	PEAK POWER LIMITED DATA ACQUISITION SAMPLING PROBLEM
2. FMCW OR INTERRUPTED FWCW	SEVERE LINEARITY REQUIREMENTS
3. CHIRP COMPRESSION	DATA ACQUISITION SAMPLING PROBLEM
4. PULSE-TO-PULSE FREQUENCY STEPPING	SYNTHESIZER SWITCHING SPEED

RANGE RESOLUTION APPROACH

- PULSE-TO-PULSE FREQUENCY STEPPING
  - COMSTRON FREQUENCY SYNTHESIZER
  - DESIRED RANGE RESOLUTION

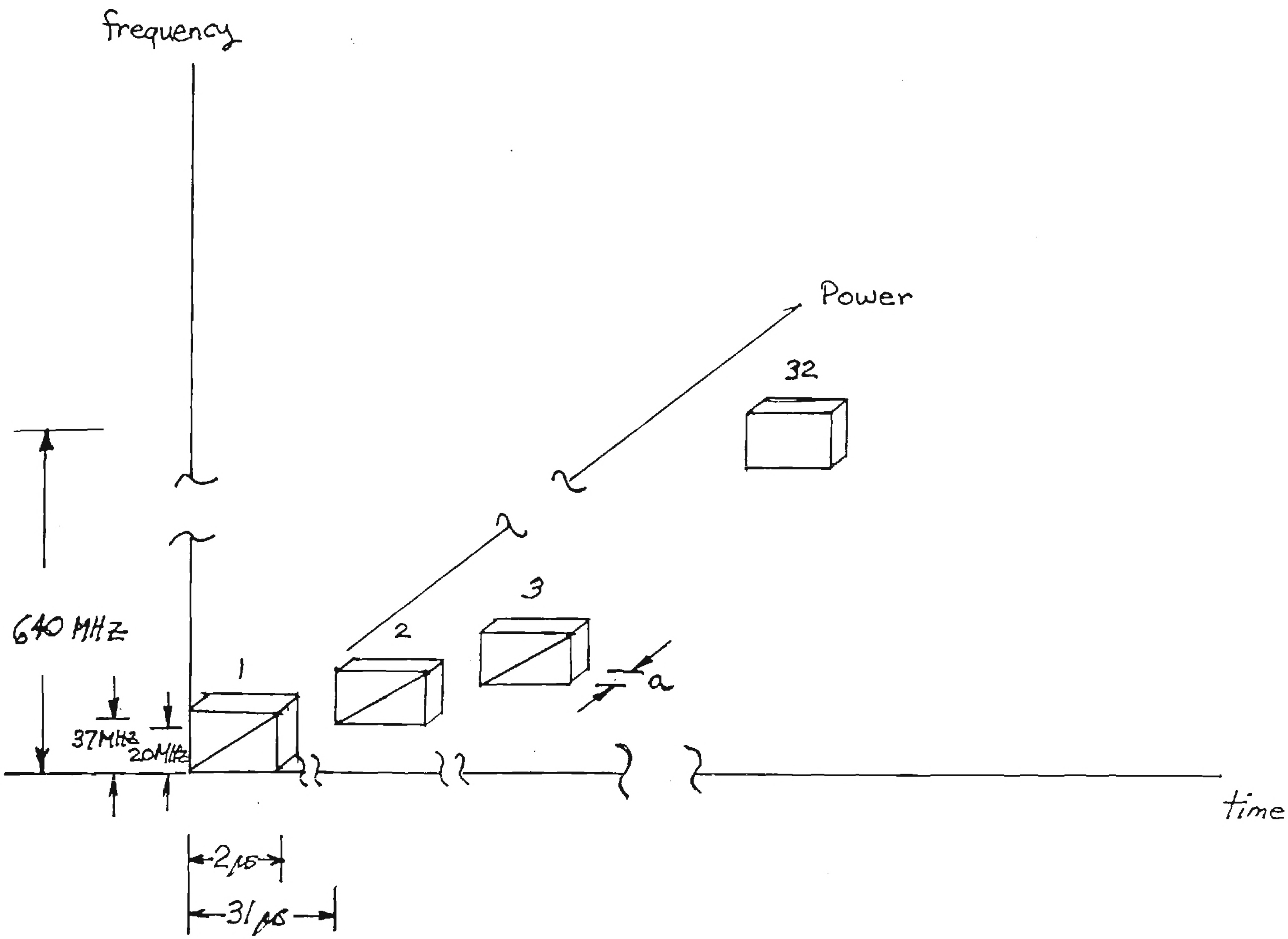
PROBLEM: SNR MARGINAL

SOLUTION: PRECEED FREQUENCY STEPPING WITH CHIRP PULSE COMPRESSION

(17 dB ADDITIONAL PROCESSING GAIN)

GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RANGE RESOLUTION APPROACH (RECEIVED SIGNAL)

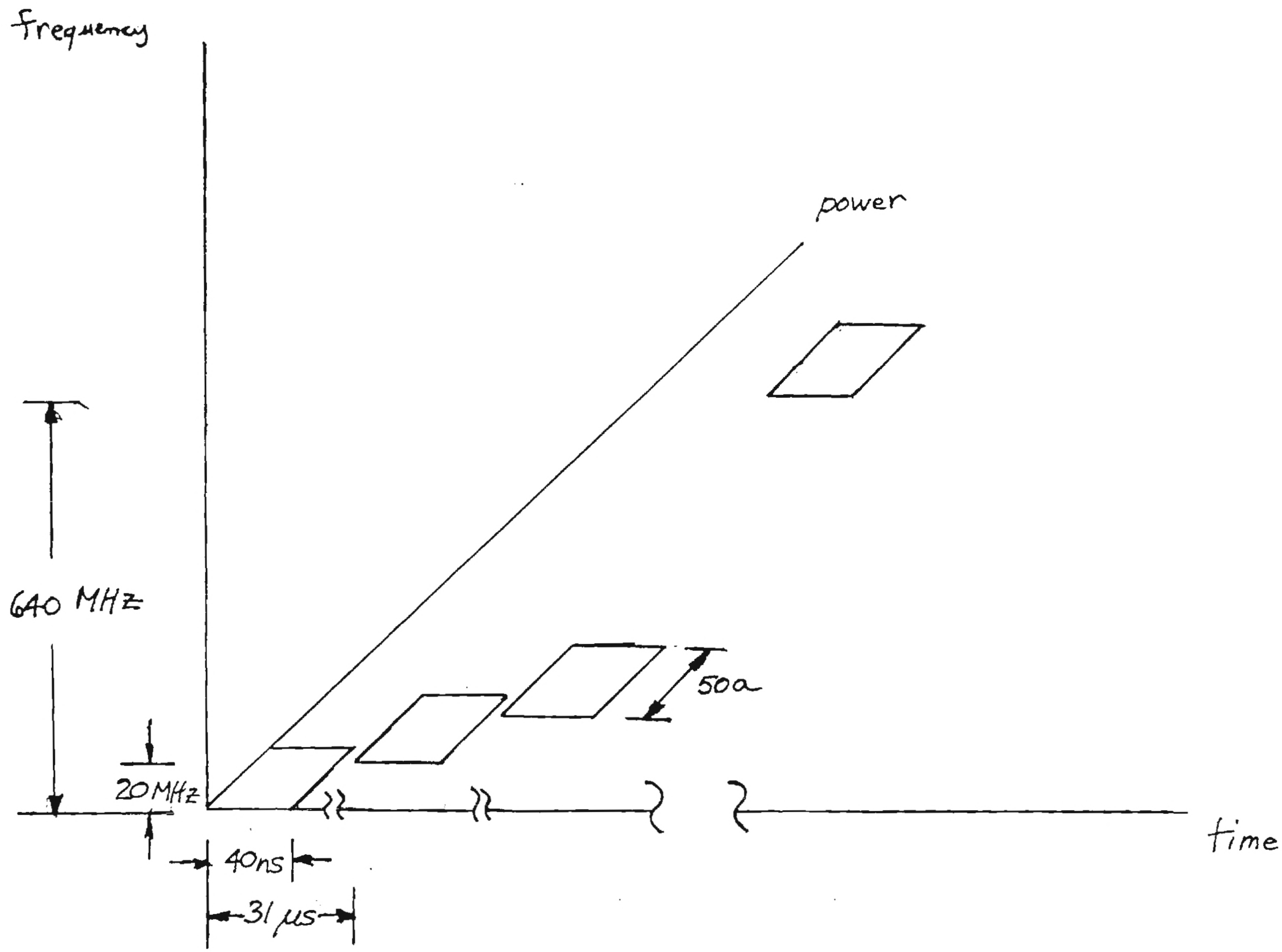


GTRI

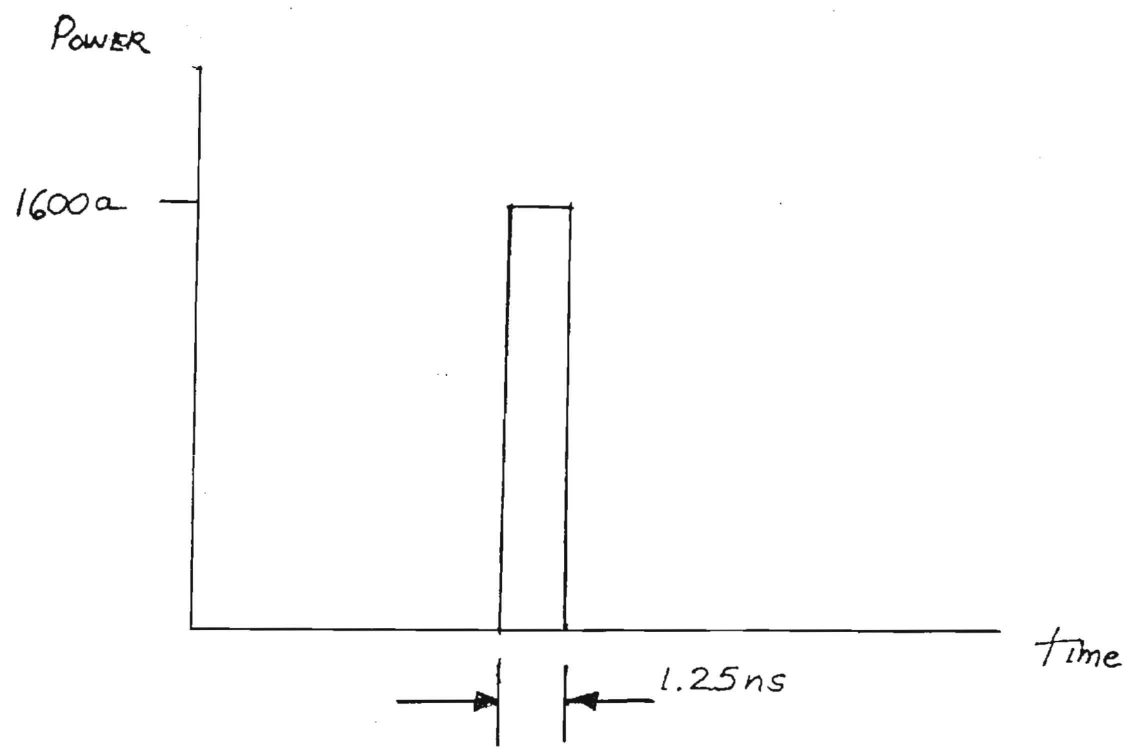
Georgia Tech Research Institute

Radar And Instrumentation Laboratory

RANGE RESOLUTION APPROACH (AFTER SAW)

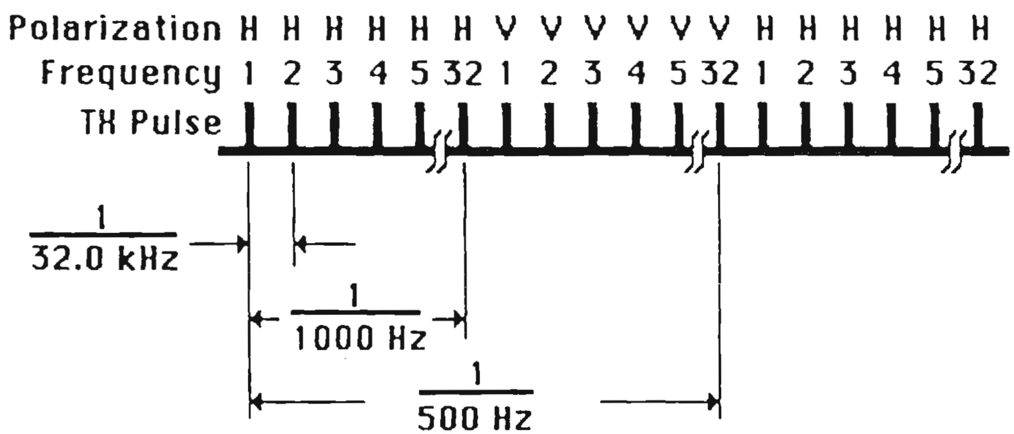


RANGE RESOLUTION APPROACH (AFTER RANGE FFT)



GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RADAR SYSTEM TIMING DIAGRAM



GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

GENERAL SAR ISSUES

- HIGH X-RANGE RESOLUTION
- LOW INTEGRATED SIDELOBE LEVEL
  - MOTION COMPENSATION
  - RANGE WALK
- MOTION COMPENSATION
- PROCESSING SPEED

PROGRAM SAR ISSUES

TEST MEASUREMENT CONDITIONS

- STRAIGHT, LEVEL, CONSTANT SPEED A/C MOTION (NO HIGH-G MANUVER)
  (HELPS MoCOMP COMPLEXITY)

- SHORT RANGES

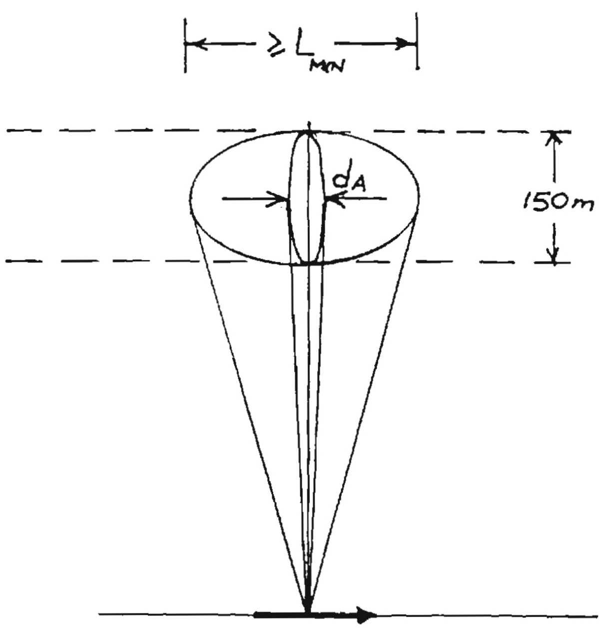
  - SHORT APERTURE TIMES (REDUCES ISL)

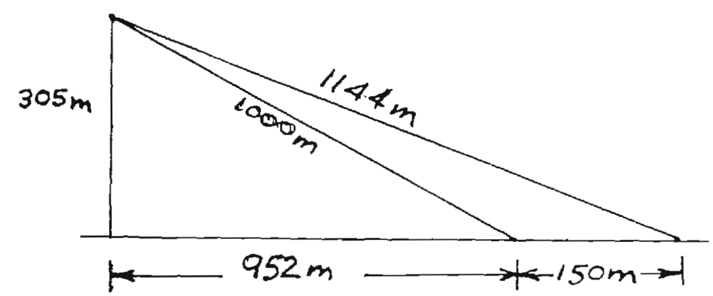
  - NO "RANGE WALK" CORRECTION (REDUCES PROCESSOR COMPLEXITY, ISL)

- NO REAL-TIME PROCESSING REQUIREMENTS AT FULL RESOLUTIONS

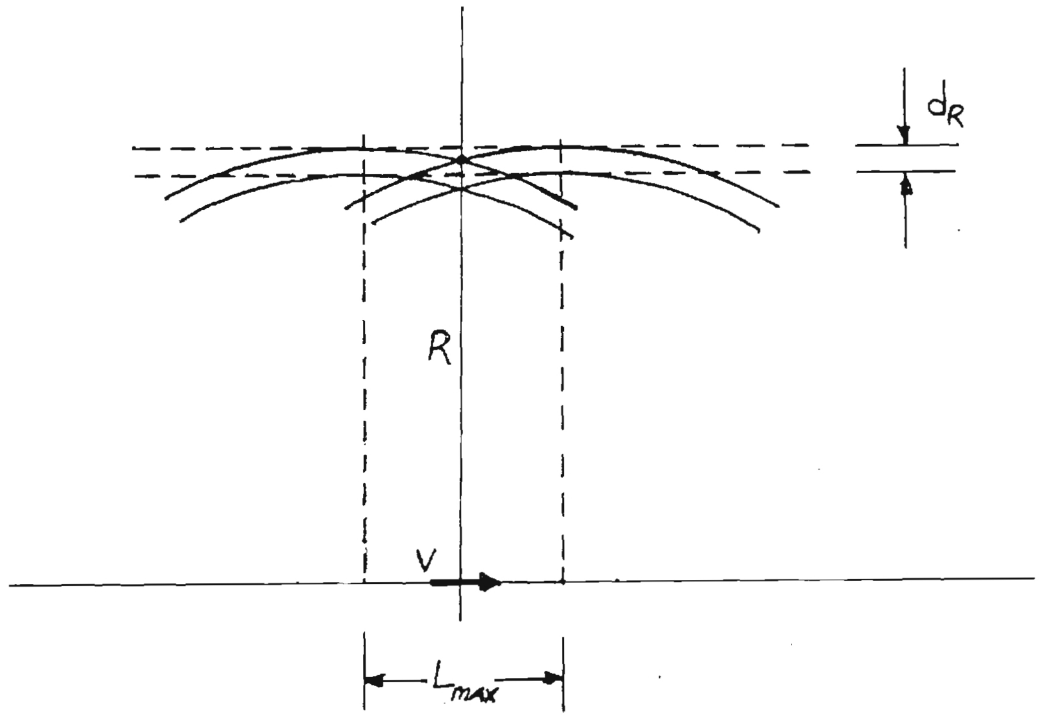
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SAR STRIP-MAP MODE





RANGE WALK (STRIP MAP MODE)



$$L_{MAX} = 2\sqrt{R d_R}$$

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SYNTHETIC APERTURE LENGTH (STRIP MAP MODE)

$d_A > \frac{\lambda R}{2L} \rightarrow L_{min} = \frac{\lambda R}{2d_A}$ (TO ACHIEVE X-RANGE RESOLUTION REQUIREMENTS)

$L < 2\sqrt{Rd_R} \rightarrow L_{max} = 2\sqrt{Rd_R}$ (TO PREVENT "RANGE WALK")

LET R_{max} BE MAXIMUM RANGE BEFORE RANGE WALK PROCESSING IS REQUIRED

$L_{min} = L_{max} \rightarrow R_{max} = 6.2$ km

GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SYNTHETIC APERTURE LENGTH (STRIP MAP MODE)

$L_{min} = 50$ ft

$R = 1085$ m

$L_{max} = 119$ ft

$L = L_{min} = 50$ ft

$\therefore$ RANGE WALK IS NOT A PROBLEM IN STRIP MAP MODE

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SAR ANTENNA X-RANGE DIMENSION (STRIP MAP MODE)

$\frac{R\lambda}{\ell} > L \quad \rightarrow \quad \ell_{max} = \frac{R\lambda}{L}$ (TO ILLUMINATE LARGE ENOUGH PATCH ON GROUND FOR X-RANGE RESOLUTION)

$\frac{2V}{\ell} < (f_r)_e \quad \rightarrow \quad \ell_{min} = \frac{2V}{(f_r)_e}$ (TO PREVENT DOPPLER AMBIGUITIES)

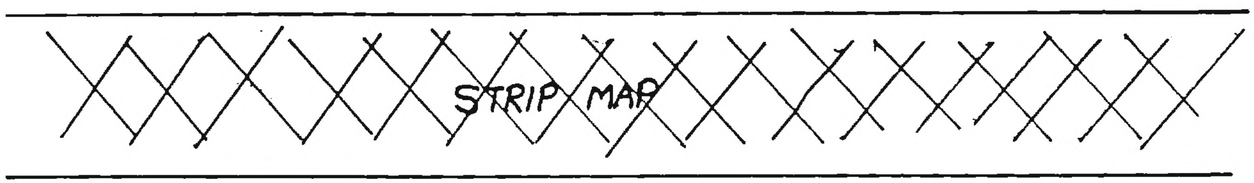
ℓ_{max} = 24 inches

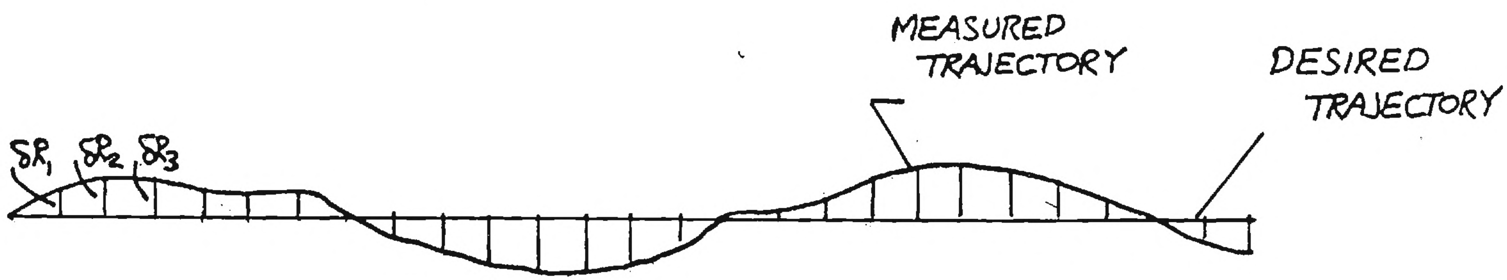
GTRI

Georgia Tech Research Institute

Radar And Instrumentation Laboratory

MOTION COMPENSATION (STRIP MAP MODE)





$\{\delta R_\ell\}$ – Line of sight range differences between measured and desired trajectories.

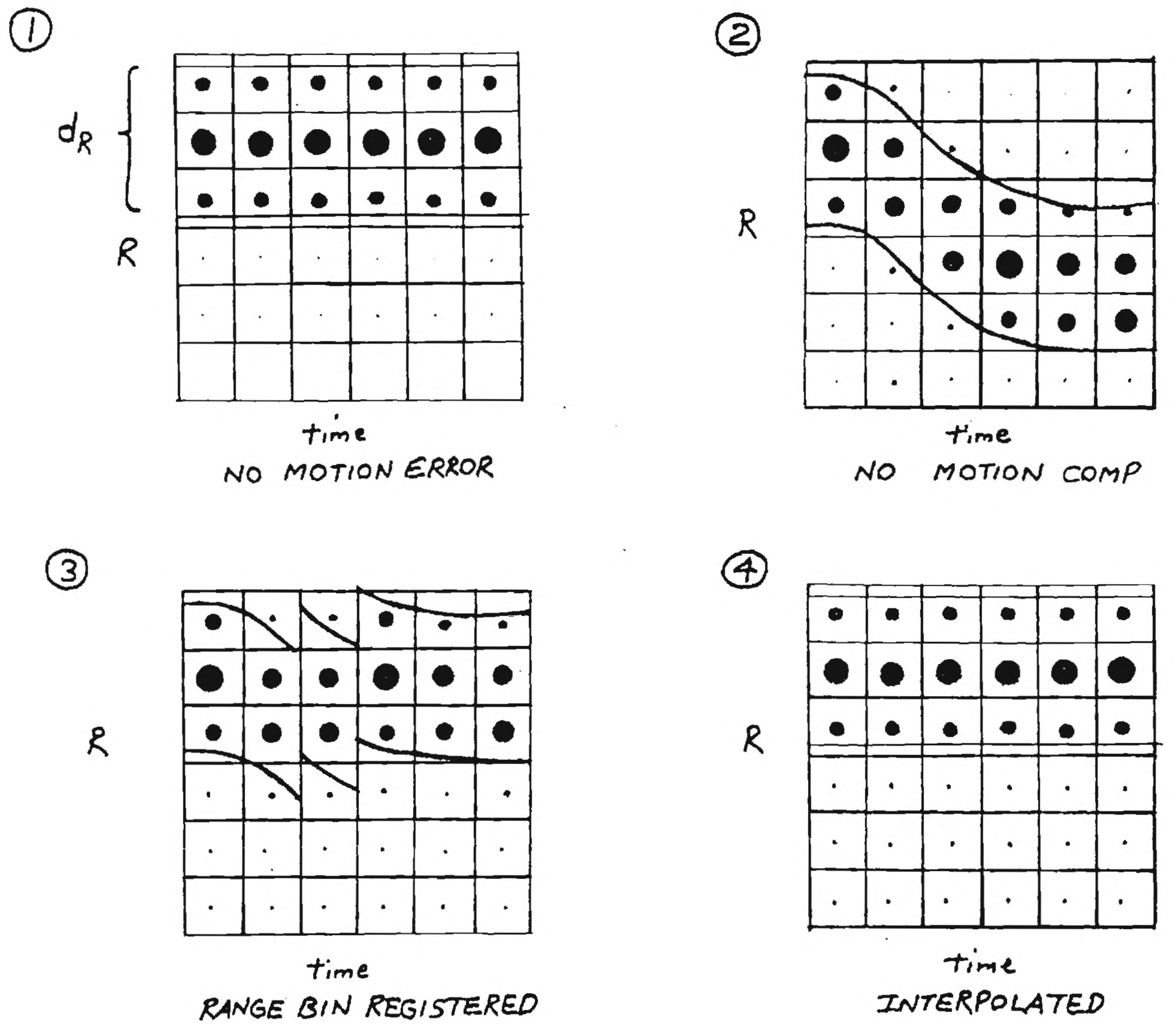
GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

MOTION COMPENSATION (STRIP-MAP MODE)

- PHASE CORRECTIONS $\Delta\phi_R = 2\pi\delta R_R/\lambda$
- RANGE BIN REGISTRATION & COMPLEX INTERPOLATION

GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RANGE BIN REGISTRATION AND INTERPOLATION



PROCESSING SPEED

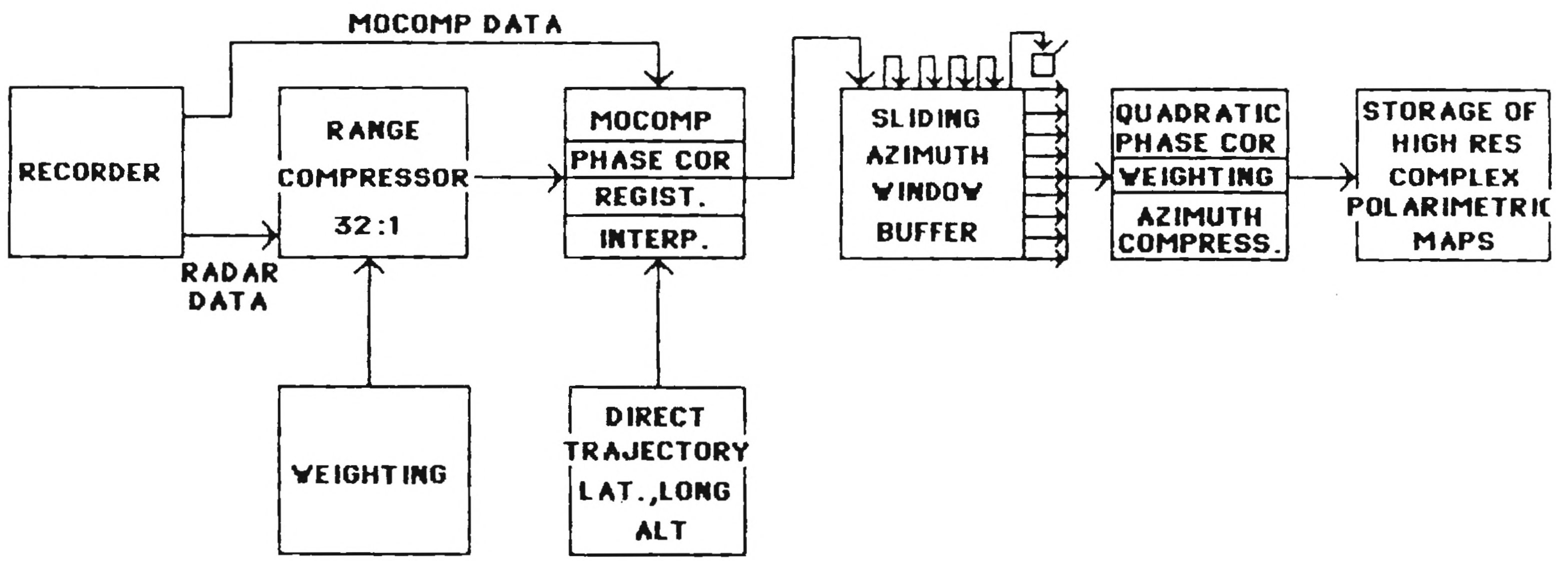
- NO REAL-TIME IMAGING REQUIREMENT

- THEREFORE, PERFORM "SLIDING WINDOW" AZIMUTHAL COMPRESSION

  - NEW RANGE SWEEP IN, OLDEST RANGE SWEEP OUT OF BUFFER
  - COMPLEX SUM IN AZIMUTH
  - PRODUCES ONE HIGH X-RANGE RESOLUTION RANGE SWEEP

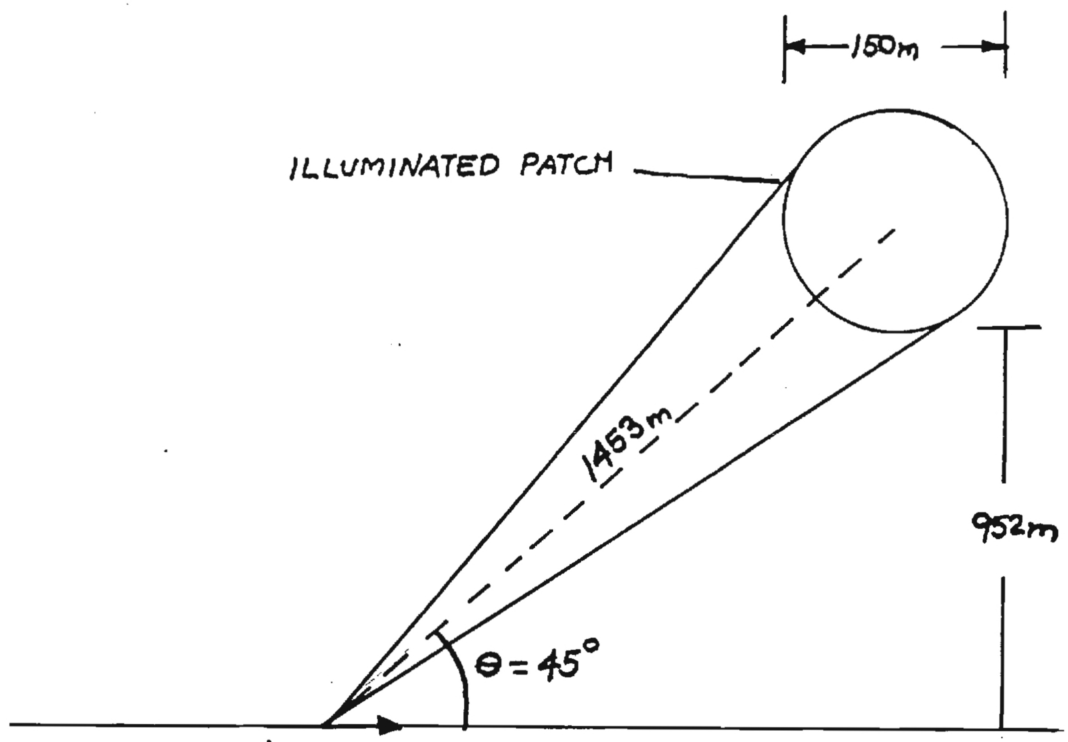
GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SAR GROUND PROCESSING STATION (STRIP MAP MODE ONLY)



Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SAR CONVENTIONAL SPOTLIGHT MODE



$-45^\circ \leq \theta \leq 45^\circ$

GTRI

Georgia Tech Research Institute

Radar And Instrumentation Laboratory

SYNTHETIC APERTURE LENGTH (CONVENTIONAL SPOTLIGHT MODE)

$d_A > \frac{\lambda R}{2L} \rightarrow L_{min} = \frac{\lambda R}{2d_A}$ (TO ACHIEVE X-RANGE RESOLUTION REQUIREMENTS)

$L < \frac{Rd_R}{L_{min}} \rightarrow L_{max} = \frac{Rd_R}{L_{min}} = \frac{2d_A d_R}{\lambda}$ (RANGE WALK)

$L_{min} = 67$ ft $\qquad R = 1453\,m$

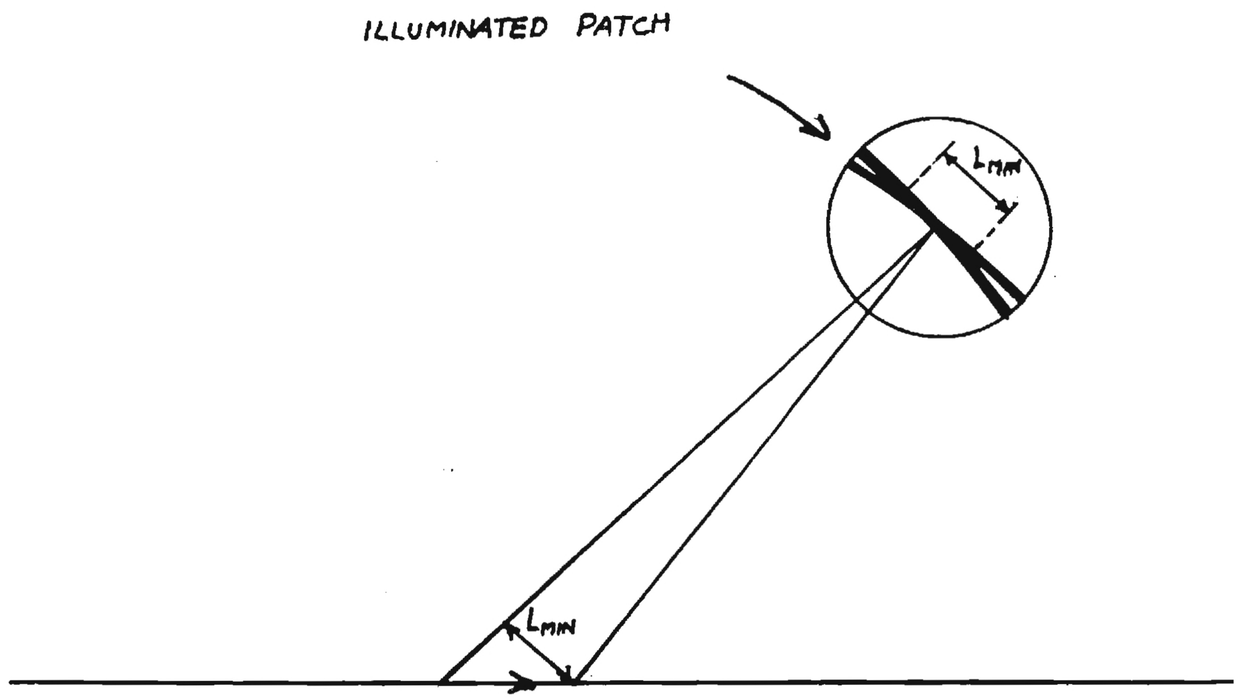
$L_{max} = 71$ ft

$\therefore$ "RANGE WALK EFFECTS BECOMING NOTICEABLE DUE TO

1. $L_{max} \approx L_{min}$
2. UN-DOPPLER PROCESSED ILLUMINATED PATCH INCREASES ISL

GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RANGE WALK
(CONVENTIONAL SPOTLIGHT MODE)



Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SAR ANTENNA X-RANGE DIMENSION (SPOTLIGHT MODE)

$\frac{R\lambda}{\ell} > W \rightarrow \ell_{max} = \frac{R\lambda}{W}$ (TO KEEP ENTIRE SPOTLIGHT AREA ILLUMINATED)

$\frac{2V}{\ell} < (f_r)_e \rightarrow \ell_{min} = \frac{2V}{(f_r)_e}$ (TO PREVENT DOPPLER AMBIGUITIES)

$$\ell_{max} = 2.4 \text{ inches}$$

IF $\ell_{min} = \ell_{max} \rightarrow f_{re} = 2.1$ kHz (3.2 kHz 50% margin)

$f_r = 136.5$ kHz (205 kHz 50% margin)

$\boxed{\text{REQUIRED PRF TOO HIGH}}$

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

MODIFIED SPOTLIGHT MODE (SQUINT STRIP-MAP/SPOTLIGHT)

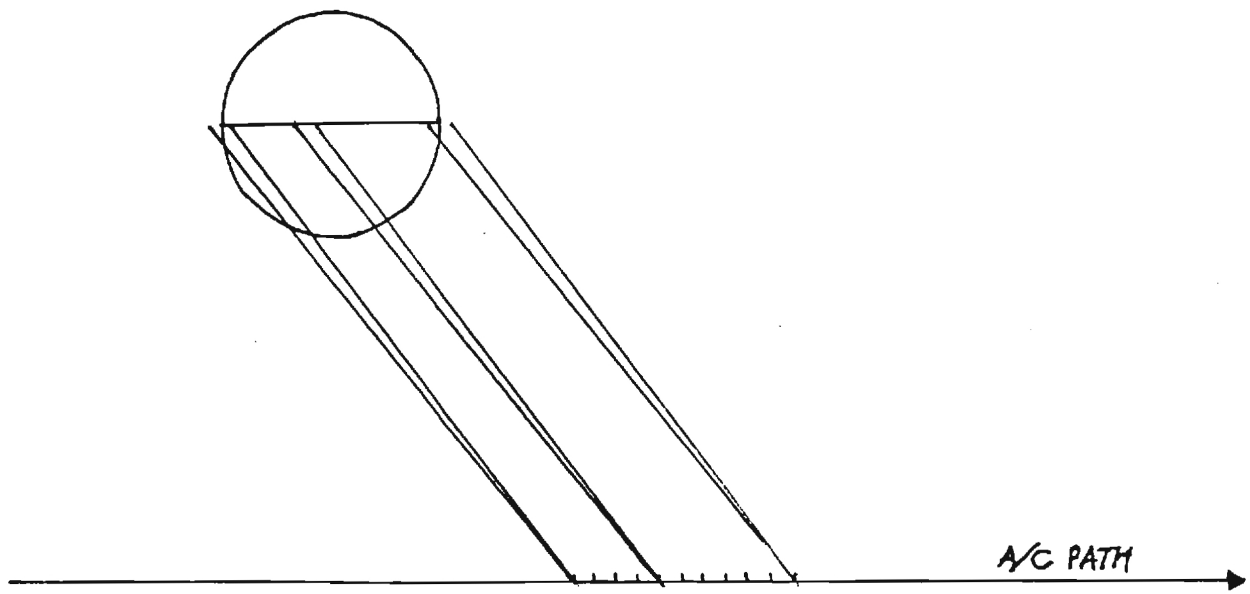
1. FIXED-ANGLE SQUINT STRIP-MAP AS REAL BEAM TRAVERSES SPOTLIGHT PATCH (SAME REAL BEAM GROUND ILLUMINATION AS IN STRIP-MAP MODE);

2. BACK-SCAN ANTENNA IN AZIMUTH TO PUT BEAM ON LEADING EDGE OF PATCH;

3. REPEAT (1) AND (2) UNTIL SQUINT ANGLE GOES FROM -45° TO 45°.

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

MODIFIED SPOTLIGHT MODE



MODIFIED SPOTLIGHT MODE ADVANTAGES

- NO RANGE-WALK PROBLEM (BACK TO STRIP MAP MODE)
- NO HIGH PRF REQUIREMENT (ILLUMINATING SMALL PATCH ON GROUND AS IN STRIP MAP MODE)
- MINIMUM DIFFERENCES BETWEEN STRIP-MAP AND SPOTLIGHT MODES:

  ANTENNA IS STEPPED-SCANNED IN AZIMUTH (EVERY 2-3 SECONDS)

  ADDITIONAL RANGE REGISTRATION/INTERPOLATION

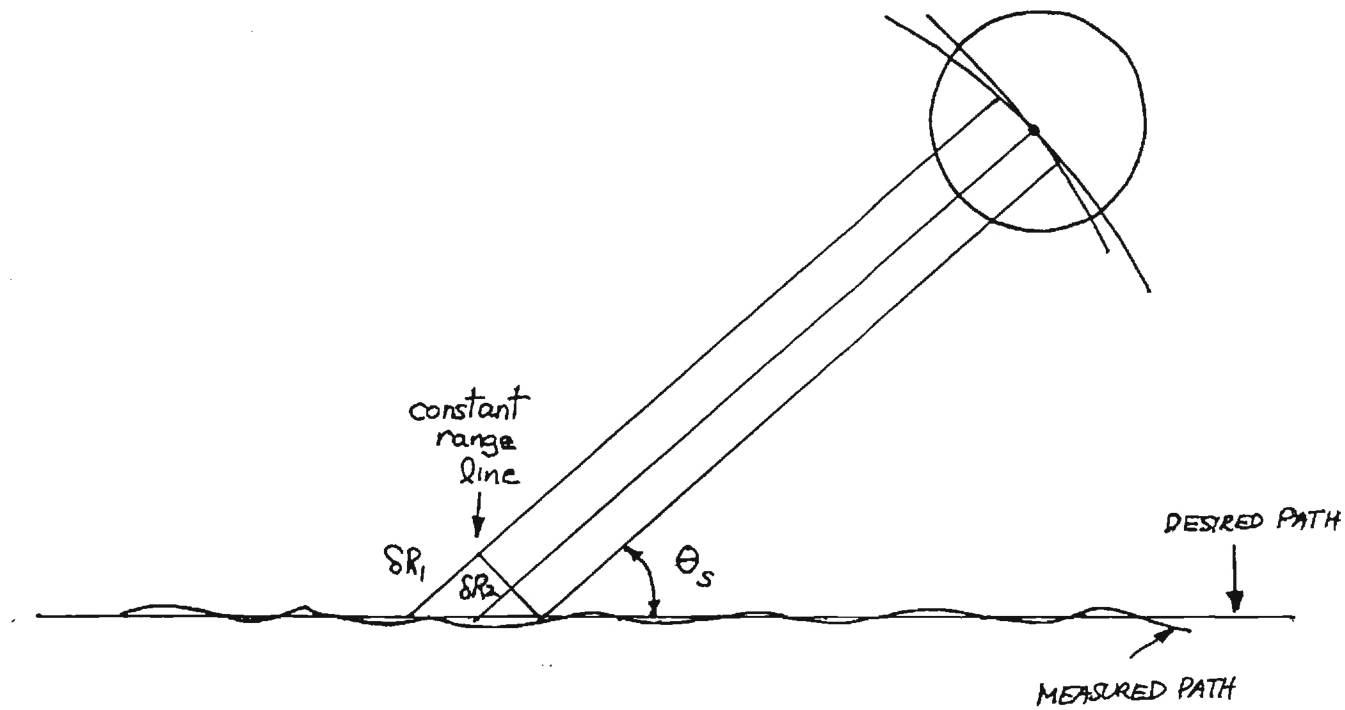
  QUADRATIC PHASE FACTOR IS FUNCTION OF SQUINT ANGLE

GTRI

Georgia Tech Research Institute

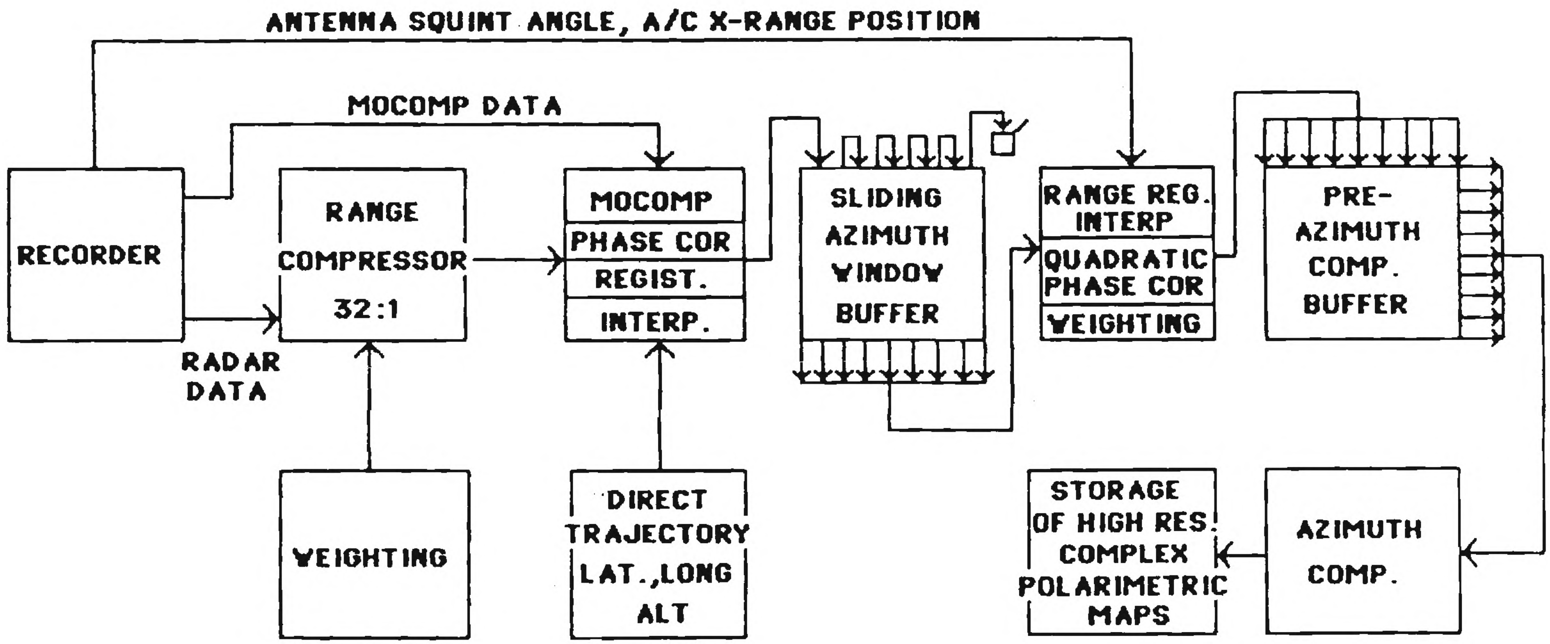
Radar And Instrumentation Laboratory

ADDITION RANGE CORRECTIONS REQUIRED WITH MODIFIED SPOTLIGHT MODE



GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SAR GROUND PROCESSING STATION (STRIP MAP & SPOTLIGHT MODES)



Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RAR APPROACH

Antenna:	1.5° El 3° Az
Scan:	$\pm 30^{\circ}$ @ 1 Hz
Range Coverage:	150 M @ 1500 M up to 30° (90 M @ 60°)
Overlap:	65 M/s Velocity
Az Resolution	40 M @ 1500 M
PRF:	500 Hz Effective
Range Resolution:	Same as SAR

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RADAR SYSTEM SALIENT FEATURES

COHERENT, FREQUENCY STEPPED, CHIRPED/COMPRESSED WAVEFORM

TRANSMITTER:

FREQUENCY:	33.2 - 33.84 GHz
PEAK POWER:	70 WATTS
PRF:	32 KHz
PULSE:	2 μsec, 37 MHz LINEAR CHIRP
FREQUENCY STEP:	32, 20 MHz STEPS

RADAR SYSTEM SALIENT FEATURES

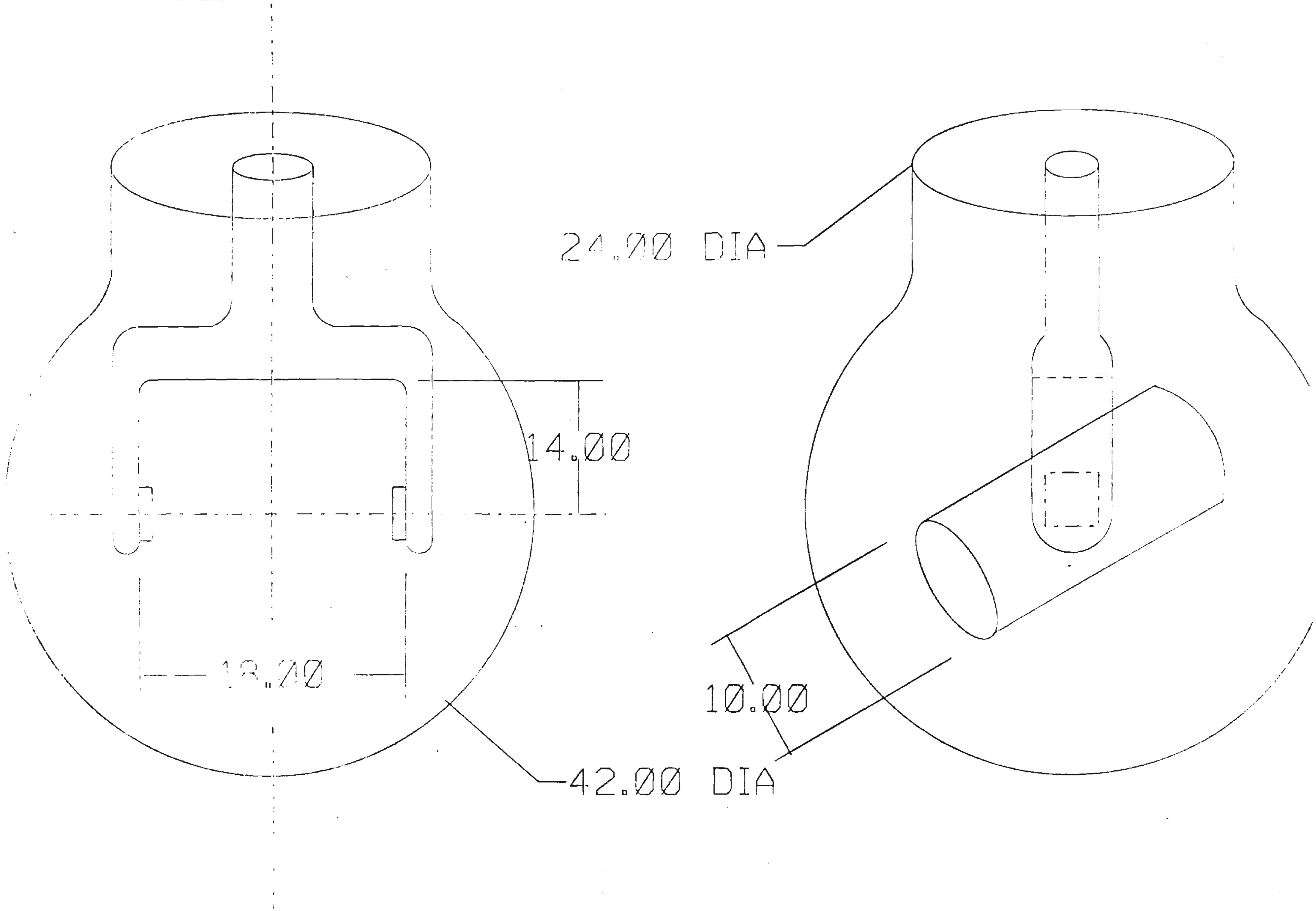
RECEIVER:

S.A.W. COMPRESSION:	50:1 TO 40 nsec
A-TO-D RATE:	32 MHz
NUMBER OF BINS:	32
FFT PROCESS/BIN:	32 POINT
NUMBER OF SYNTHETIC BINS:	1024
SYNTHETIC PULSE LENGTH:	$\approx$2 nsec
EFFECTIVE PRF:	500 Hz/POLARIZATION

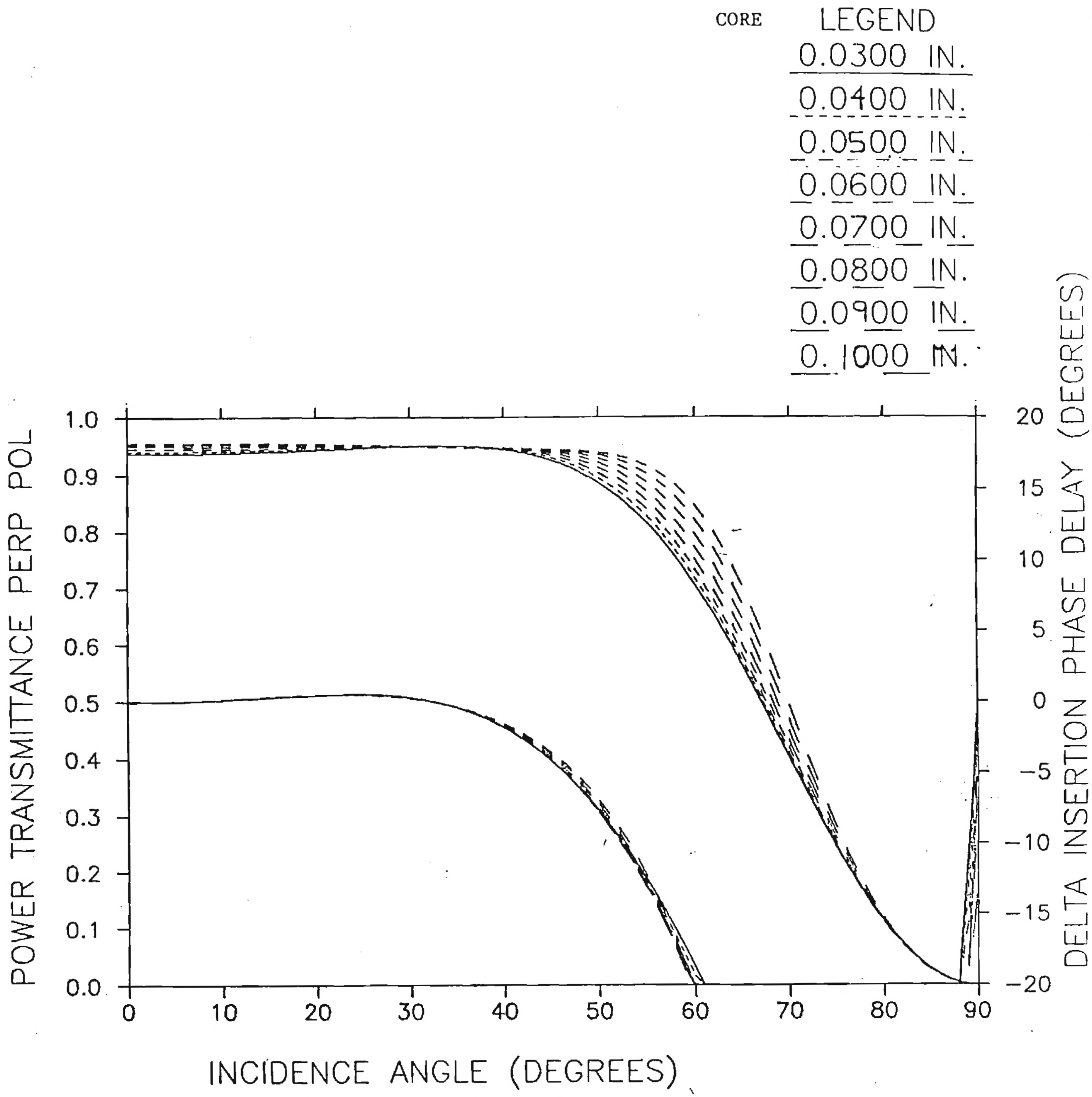
RADAR SYSTEM SALIENT FEATURES

ANTENNA: HORN - FED LENS (SAR, RAR)

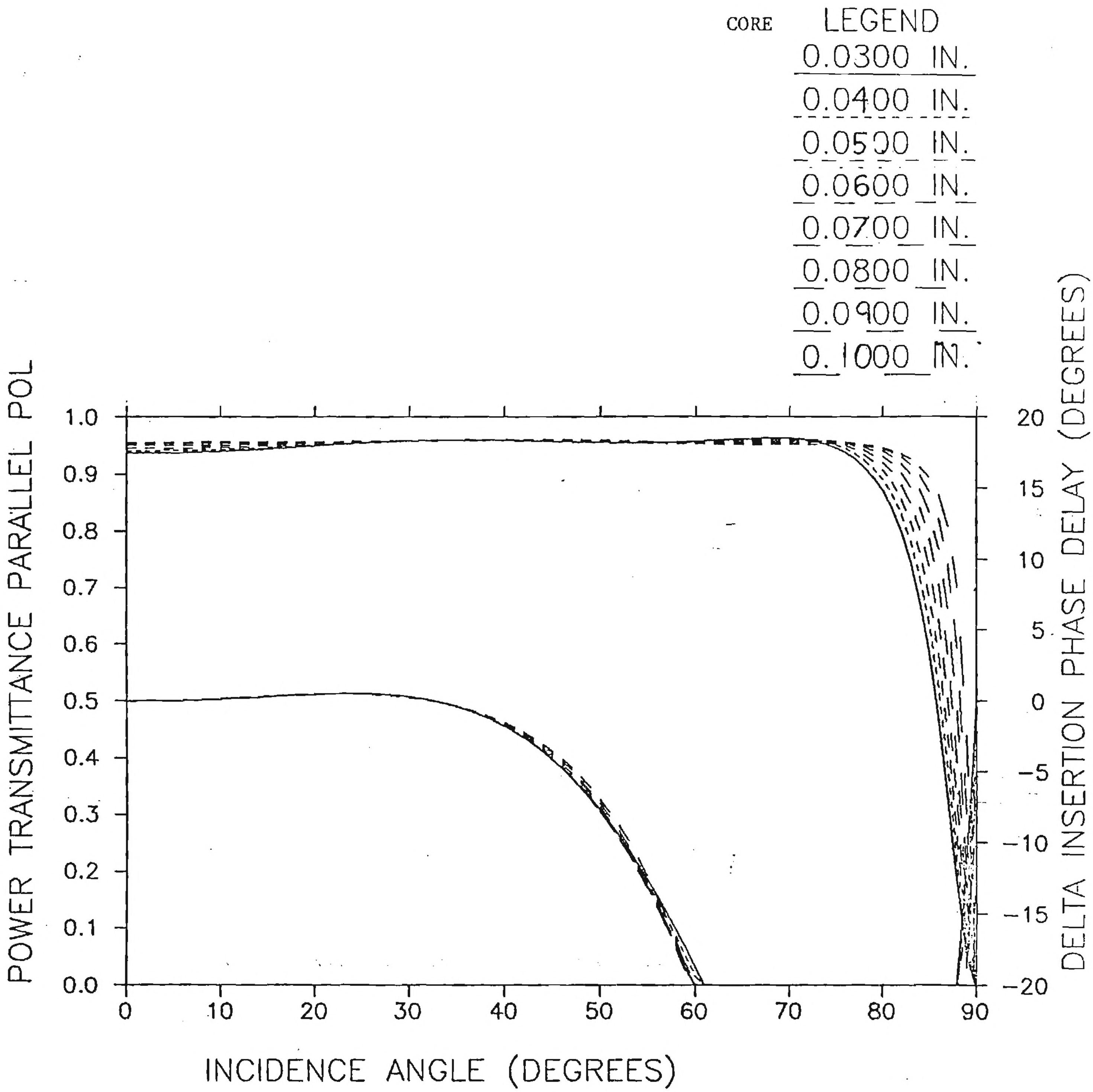
AZ:	1.5° (.43M)
EL:	3.0° (.22M)
GAIN:	38 dB
SIDELOBES:	30 dB PEAK
POLARIZATION:	25 dB ISOLATION, 1.0 dB ELIPTICITY



24.00 DIA
14.00
18.00
10.00
42.00 DIA



A-SANDWICH (3 LAYER) RADOME WALL − F/34.0 - 2 Half-wave Skins



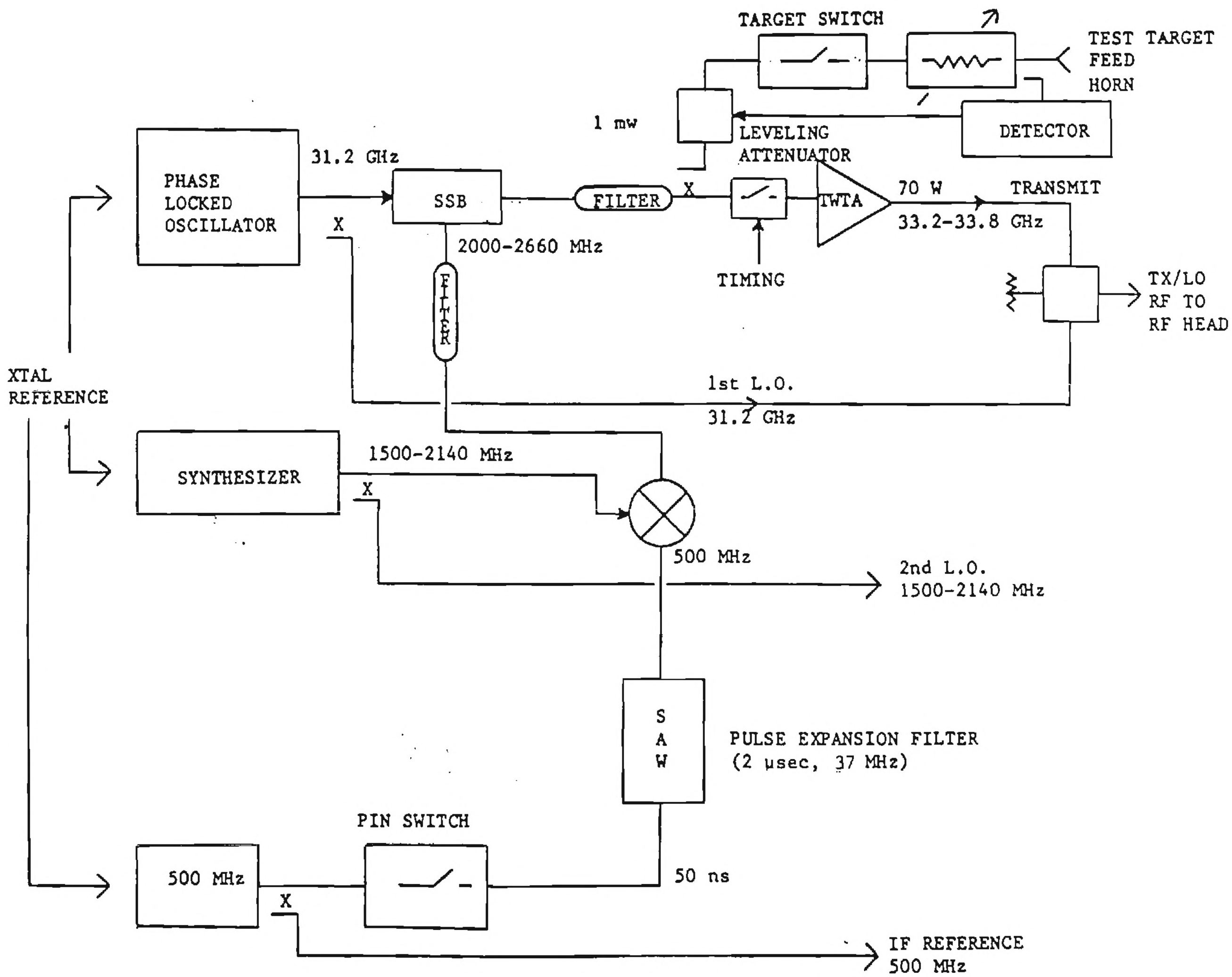
-SANDWICH (3 LAYER) RADOME WALL – F/34.0 2 Half-wave Skins

GTRI

Georgia Tech Research Institute

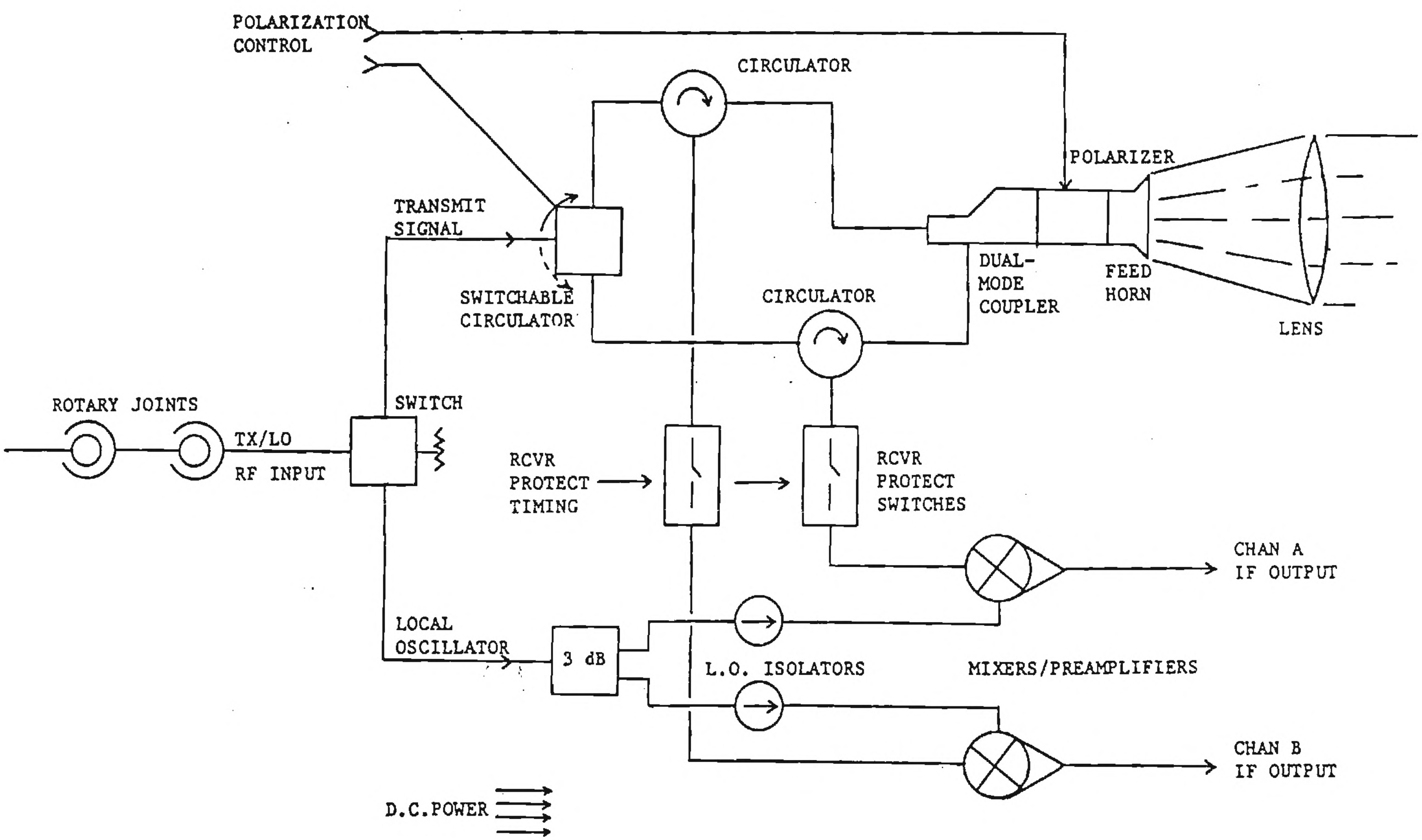
Radar And Instrumentation Laboratory

RF SUBSYSTEM



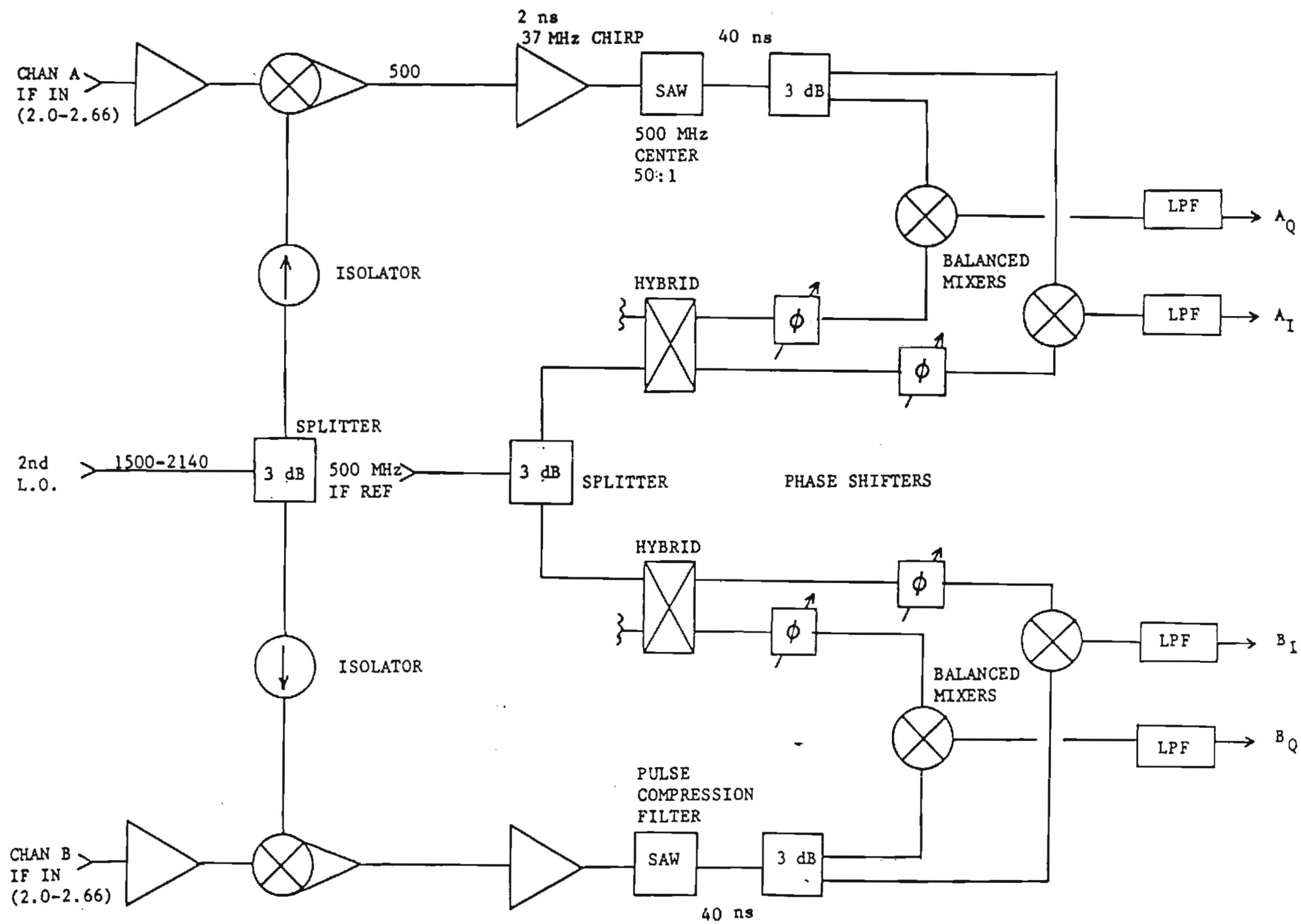
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RF HEAD



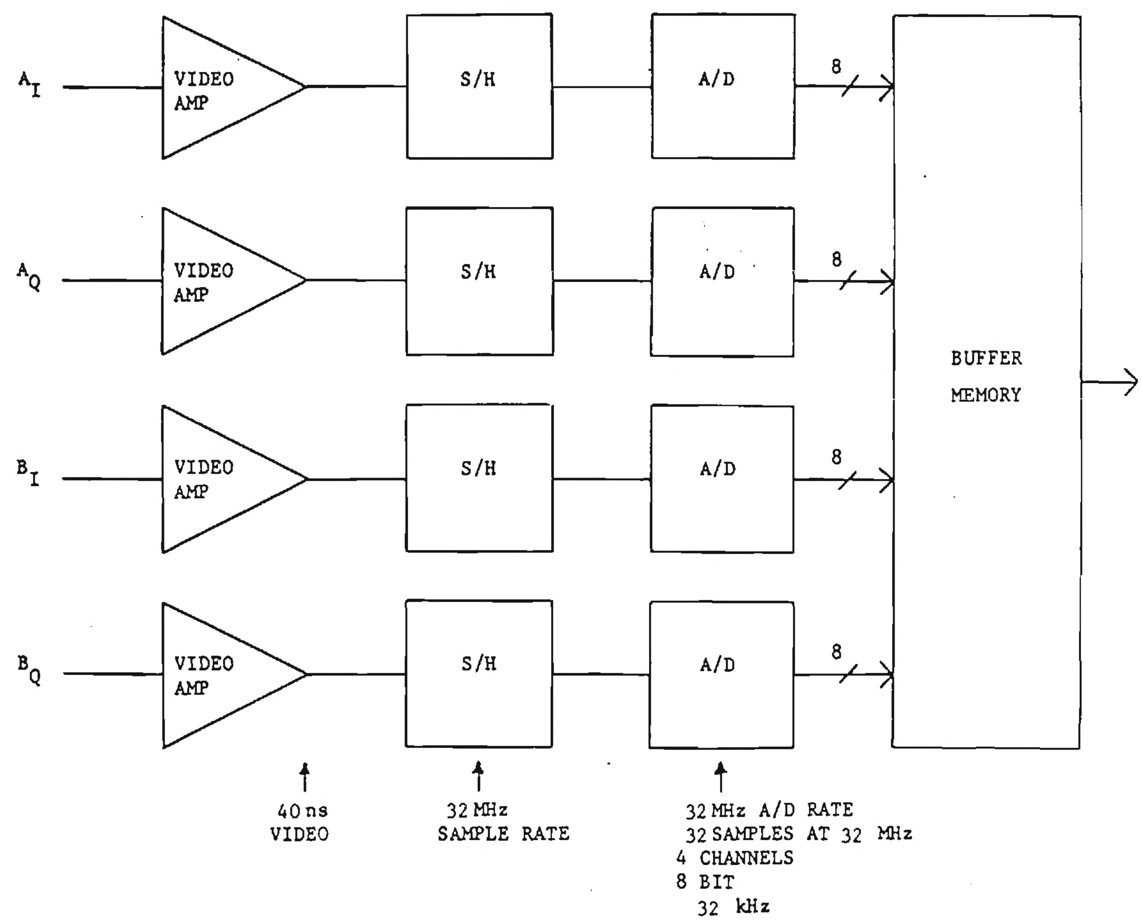
GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

IF SUBSYSTEM



GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

RADAR DATA ACQUISITION SUBSYSTEM



AIRBORNE DATA ACQUISITION AND SYSTEM CONTROL

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

OBJECTIVES

1. Record radar reflectivity, motion compensation data, time codes, status flags, etc.
2. Provide range gate delay to the analog-to-digital converters.
3. Control antenna pointing direction.
4. Provide built-in test capability.
5. Provide in-flight assessment of data quality

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

APPROACH

1. Record digitized I and Q, range-gated, video returns for both receiver polarization channels.

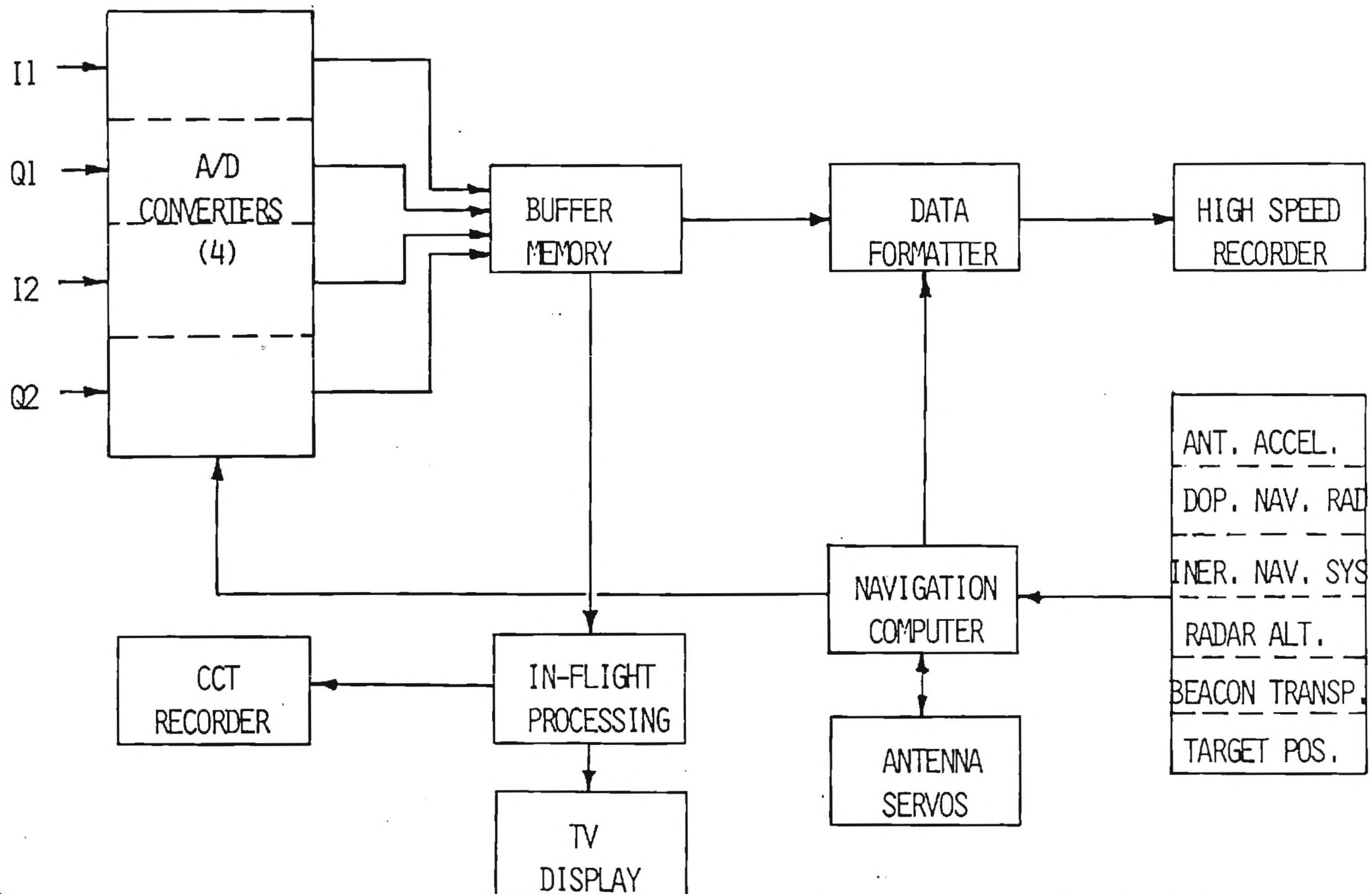
2. Utilize 3-axis accelerometers, Doppler navigation radar, and inertial navigation systems to provide antenna position data to be used for motion compensation.

3. Utilize aircraft and target position data plus the beacon transponder return to provide proper antenna pointing directions.

4. Monitor transmitter power, receiver output levels, noise levels; provide for signal calibration.

5. Provide in-flight ability to assess data quality by displaying medium resolution radar imagery in "real time."

SIMPLIFIED BLOCK DIAGRAM



Georgia Tech Research Institute
Radar And Instrumentation Laboratory

ANALOG-TO-DIGITAL DATA CONVERSION

- 8-bit, 32 MHz A/D converters are off-the-shelf items.
- Range gate delay will be provided by the navigation computer from stored target position data and calculated aircraft position data.
- Four A/D converters are required for full polarization matrix data collection capability.
- An oversampling of the range dimension data by a factor of 1-1/2 is provided.

BUFFER MEMORY

- The data rate from the A/D converters is slowed down from a burst rate to a steady rate into the recorder formatter.
- Buffering is performed on all four receiver channels simultaneously at the pulse repetition rate.

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

NAVIGATION SENSORS

ANTENNA ACCELEROMETERS	3-axis system provides $\ddot{x}$, $\ddot{y}$, and $\ddot{z}$ on the gimbol.
DOPPLER NAVIGATION RADAR	True ground speed is provided from $\dot{x}$, $\dot{y}$, and $\dot{z}$ of the aircraft.
INERTIAL NAVIGATION SYSTEM	Latitude, longitude, and height plus roll, pitch, and yaw are provided
RADAR ALTIMETER	Relative height of the aircraft to the local terrain below the aircraft is provided.
BEACON TRANSPONDER	Specific target area locations are designated.
TARGET POSITIONS	Stored target position information will be referenced to beacon transponder locations.

NAVIGATION COMPUTER

- Provides range gate delay to the A/D converters for sampling initiation.
- Calculates antenna pointing direction.
- Commands the gimbal position.
- Compares gimbal position to command position as part of built in test.

HIGH SPEED RECORDER

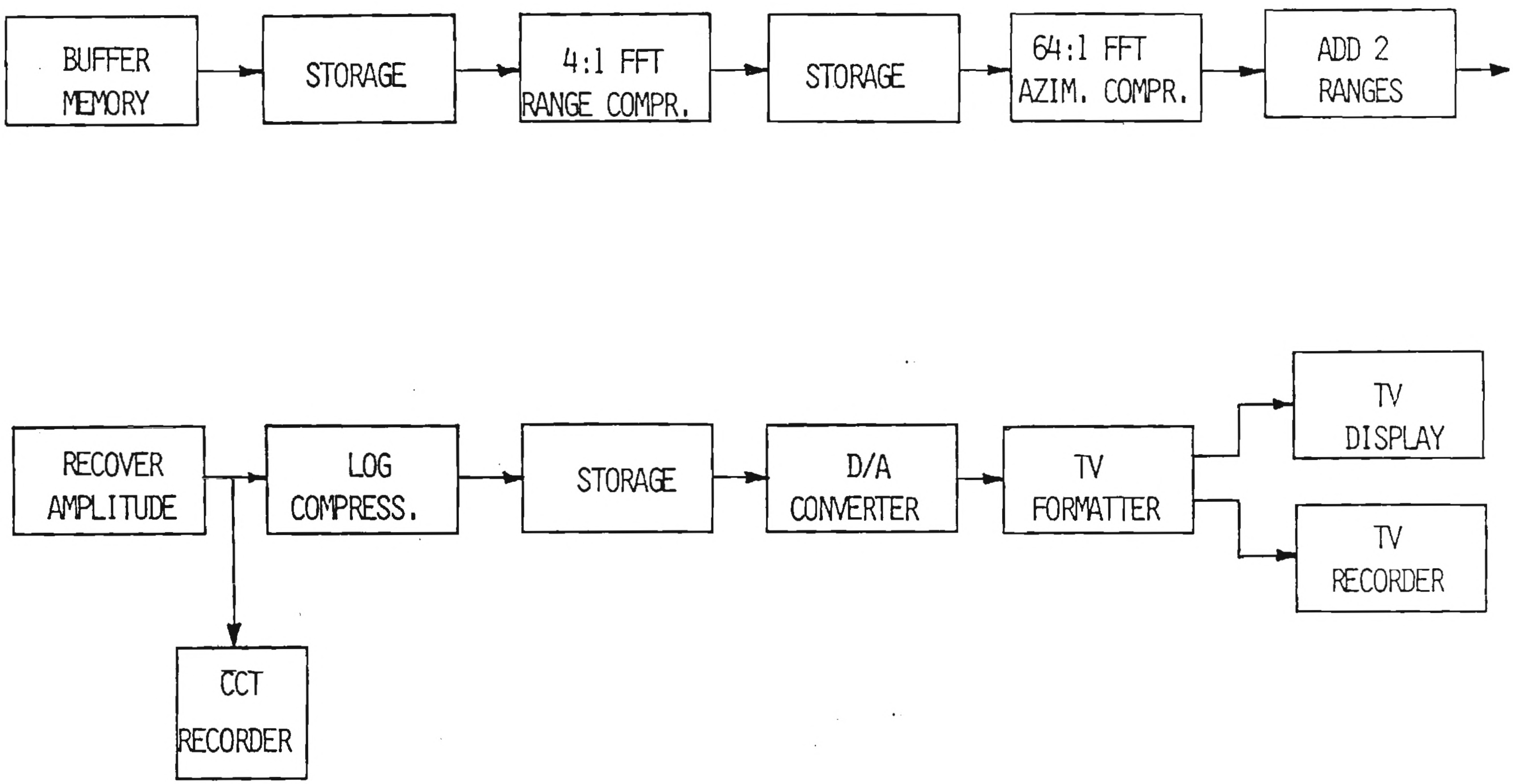
- Duplicate of the ground-based recorder, except possibly for playback capability.
- Georgia Tech requests that high speed recorders be Government furnished equipment.
- Provides a digital tape that contains all sampled radar video signals, motion compensation data, time code data, polarization status flags, range bin position, etc.

IN-FLIGHT DATA PROCESSING OBJECTIVES

- Processing provides an ability to assess the quality of the radar data in a "real time" manner.
- Processing provides a means of documenting radar scenes in a television compatible format.

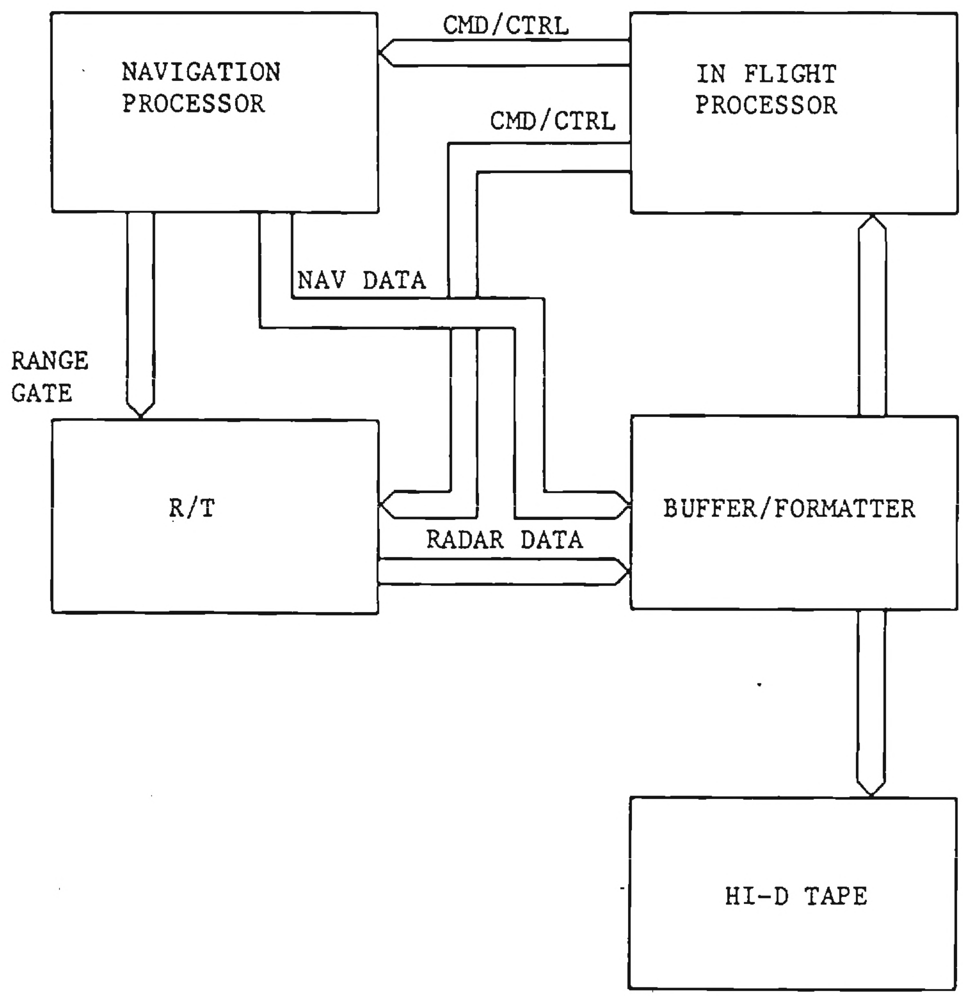
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

IN-FLIGHT DATA PROCESSING



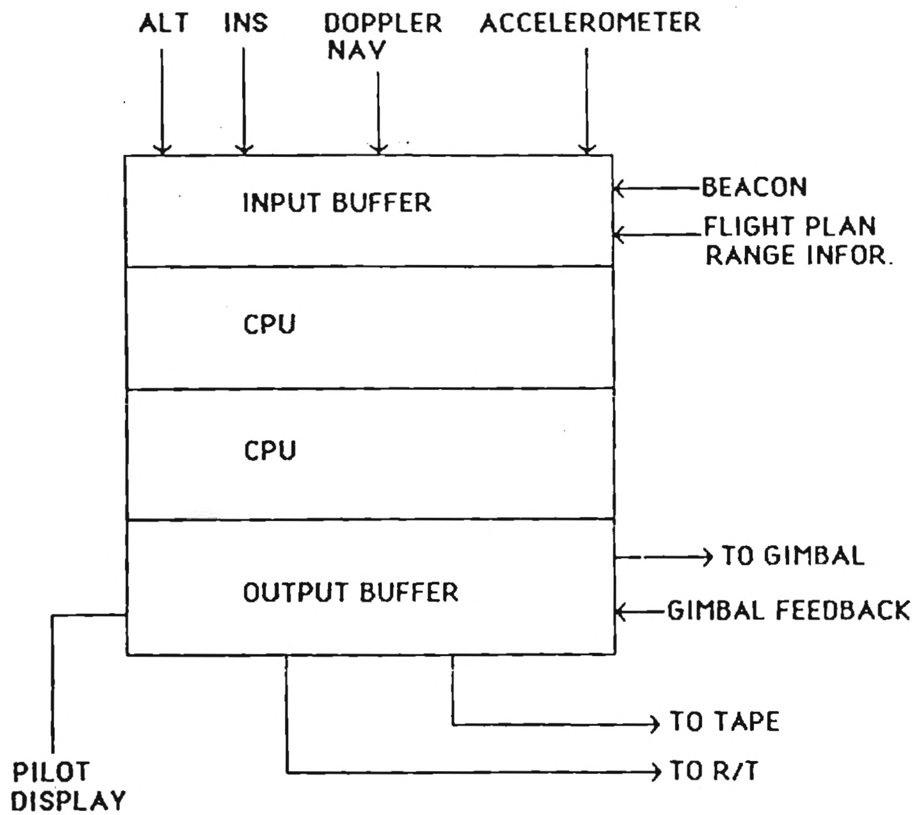
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

AIRBORNE DIGITAL SYSTEM - OVERVIEW



GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

NAV AND STABILIZATION PROCESSOR



RECORD FORMAT

INS $\Lambda, \lambda, h, R, P, Y$

D.N $\dot{X}, \dot{Y}, \dot{Z}$

ACCEL. $\ddot{X}, \ddot{Y}, \ddot{Z}$

ALT. ALT

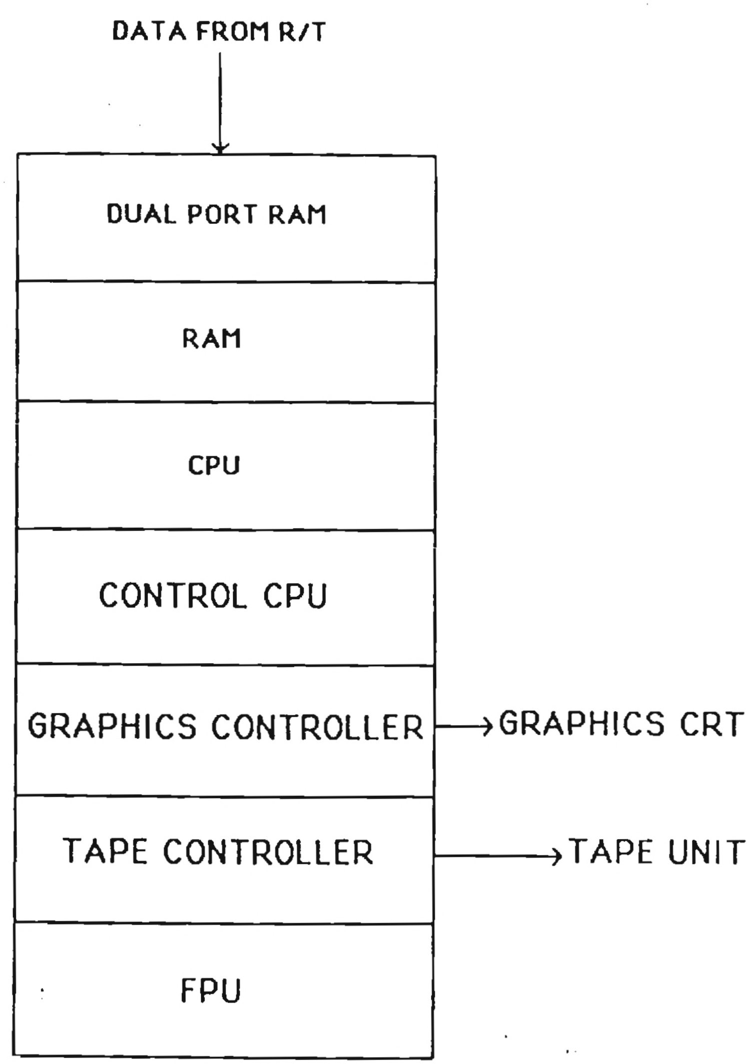
GIMBAL COMM. AZ, EL

GIMBAL FEEDBACK AZ, EL

RANGE RATE DIGITAL COUNT

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

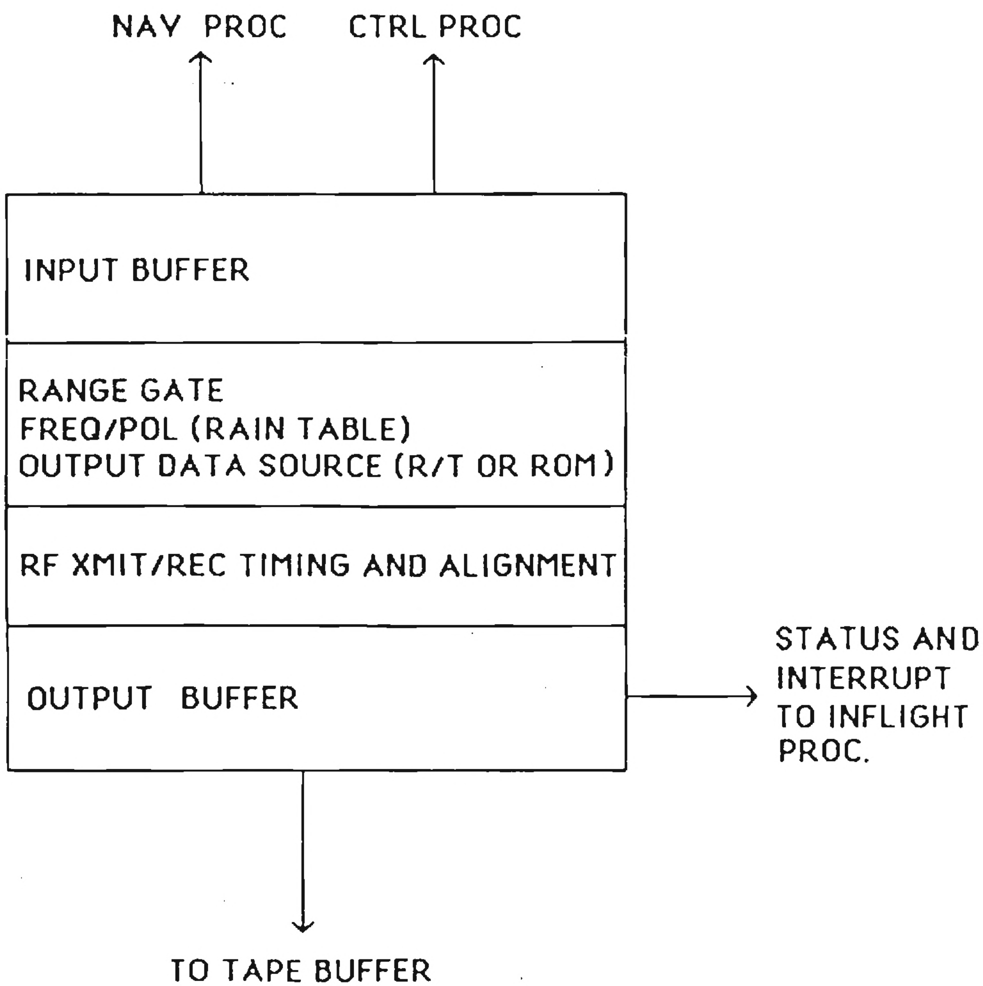
IN FLIGHT DATA PROCESSOR



Georgia Tech Research Institute

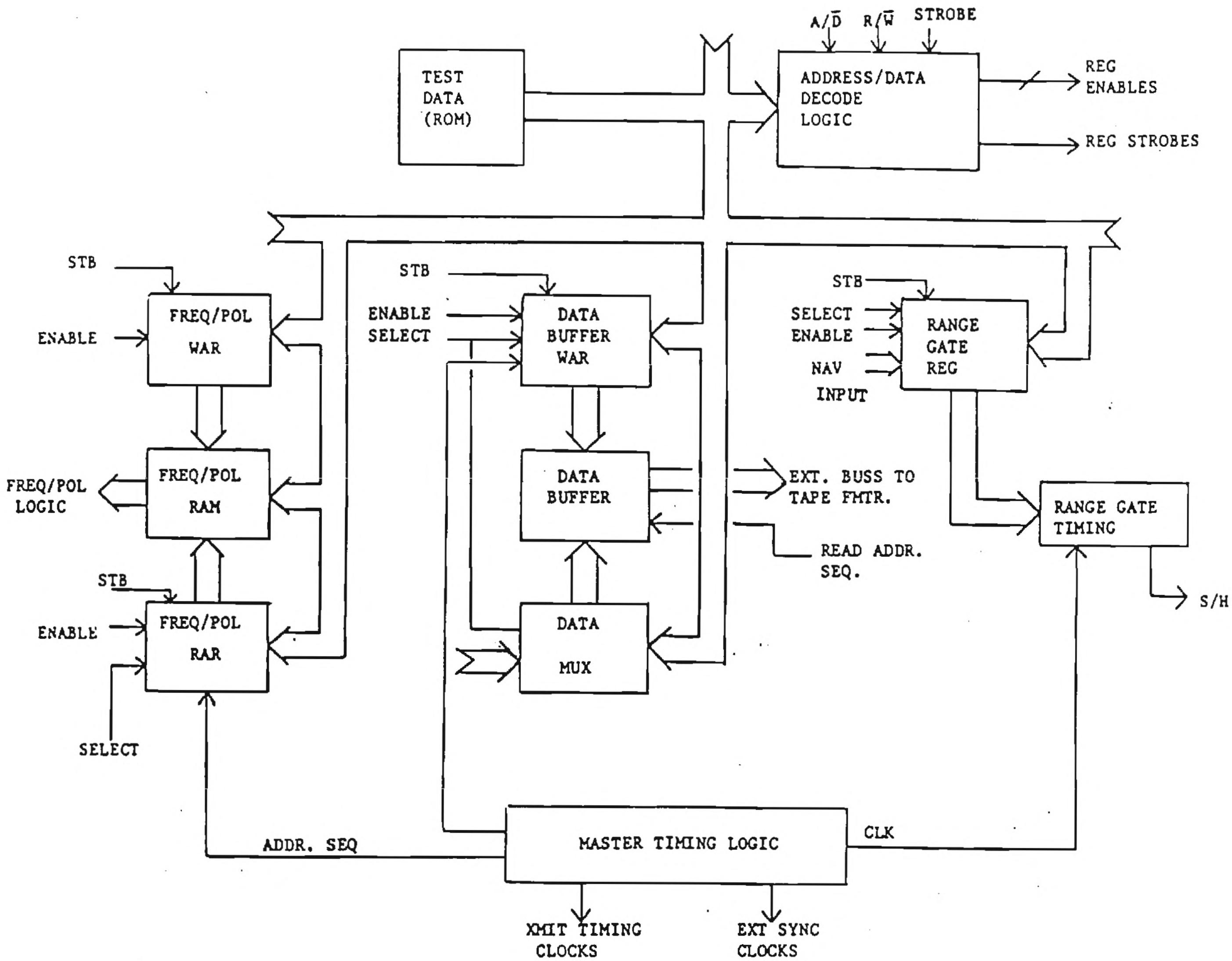
Radar And Instrumentation Laboratory

R/T DIGITAL SUBSYSTEM



GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

R/T DIGITAL SUBSYSTEM OVERVIEW

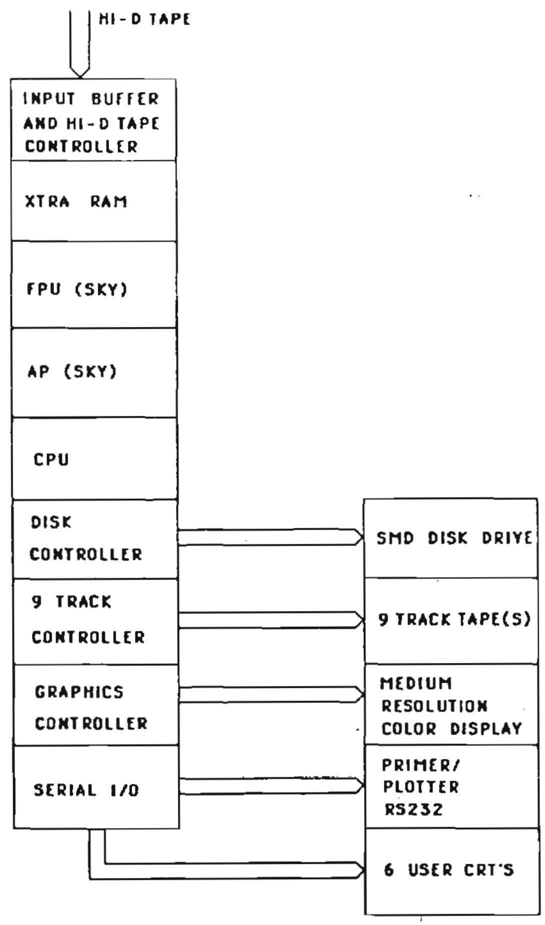


GROUND BASED DATA ACQUISITION

- COMMERCIAL 32-BIT MICROPROCESSOR BASED TECHNOLOGY
- REAL TIME PROCESSING APPROACH
- QUICK LOOK PROCESSING
- DATA BASE PROCESSING
- INFLIGHT DEVELOPMENT SYSTEM
- PROCESSOR COMMONALTY
- COMPACT SYSTEM

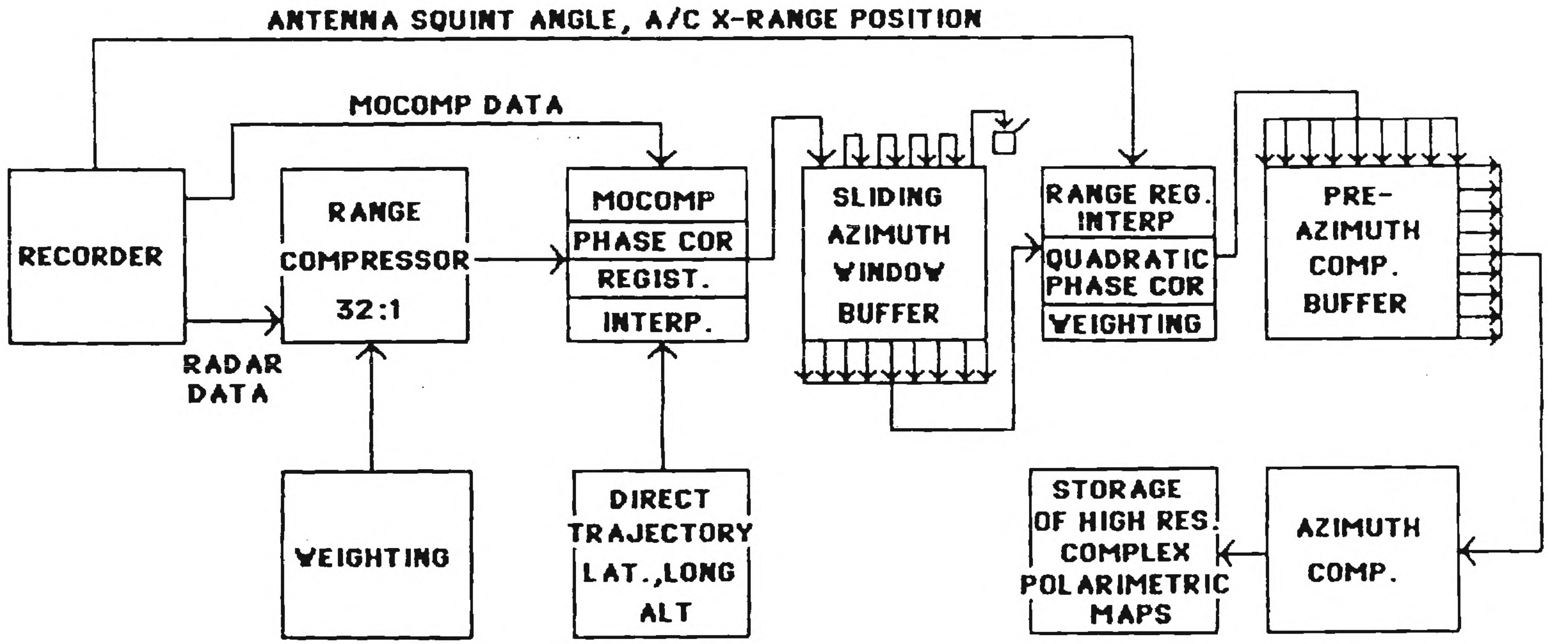
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

GROUND BASED ANALYSIS SYSTEM



GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SAR GROUND PROCESSING STATION (STRIP MAP & SPOTLIGHT MODES)



GROUND BASED PROCESSING SUMMARY

- QUICK LOOK CALIBRATION VERIFICATION
- QUICK LOOK BITE ANALYSIS
  - GIMBAL POINTING
  - R/T TEST TARGET
  - R/T PERFORMANCE ANALYSIS
- QUICK LOOK SCENES

  11 MIN - SAR
  24 MIN - SPOTLIGHT
- CALIBRATED DATA BASE

SYSTEM CALIBRATION

AMPLITUDE

- Pre and Post Flight Calibrations (Ground)
- In Flight Calibration
- Calibration Assessment (Quick Look)

RESOLUTION

- In Flight Calibration
- Calibration Assessment

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

AMPLITUDE PRE AND POST FLIGHT CALIBRATION

- SIGNAL INJECTION (RECEIVER TRANSFER CURVE)
  + INJECT TRANSMITTED SIGNAL INTO RECEIVER AT ALL FREQUENCIES
  + VARY POWER LEVEL FROM RECEIVER SATURATION TO NOISE
- CALIBRATED TARGET STARE (ABSOLUTE CALIBRATION)
  + STARE AT ONE OR MORE ODD BOUNCE TARGETS AND ONE OR MORE EVEN BOUNCE TARGETS
  + PLACE TARGETS AT PROPER HEIGHT TO ELIMINATE MULTIPATH

IN FLIGHT CALIBRATION

- Fly Over Calibrated Target Array
  - + Even and Odd Bounce Targets
  - + Varying Distances Between Targets
  - + Optical Markers for TV Viewing

CALIBRATION ASSESSMENT

- Compare Injected Signal Transfer Curve to Absolute Ground Calibration Using Radar Equation
- Compare In Flight Array Calibration to Ground Calibration
- Two Independent Calibration Checks

RESOLUTION CALIBRATION

INFLIGHT CALIBRATION

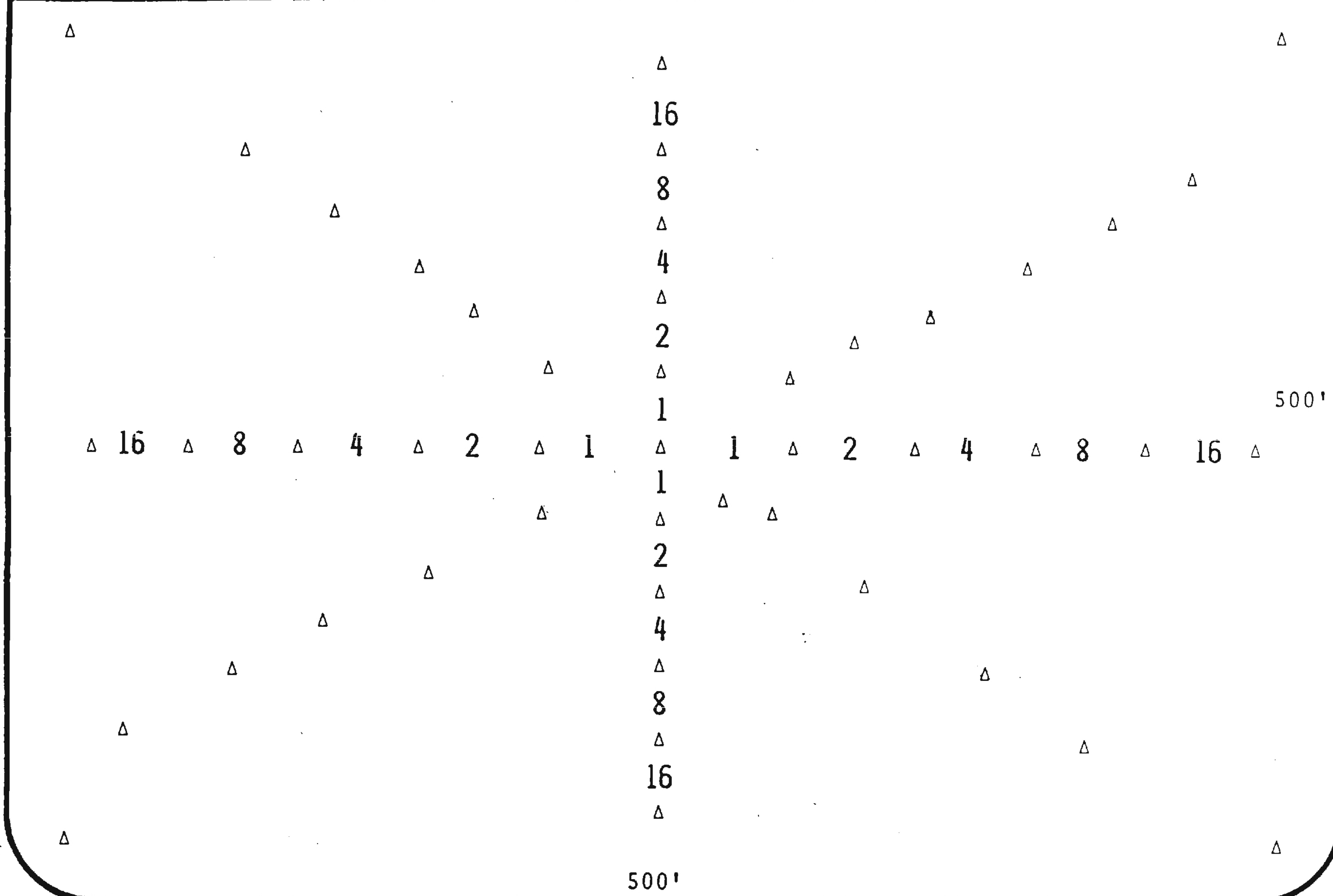
- Fly Over Radar Reflector Array with Varing Distance Between Reflectors

RESOLUTION ASSESSMENT

- Display Calibration Data on XY Display
- Determine the Resoluable Reflector Distance

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

CALIBRATION REFLECTOR ARRAY



Georgia Tech Research Institute
Radar And Instrumentation Laboratory

DAILY FLIGHT TEST PROCEDURES

- SYSTEM CHECK OUT
- GROUND CALIBRATION
  - SIGNAL GENERATOR
  - ABSOLUTE STARE
- FLIGHT CALIBRATION (FLY OVER REFLECTOR ARRAY)
- BEGIN FLIGHT TESTS
  VIEW MEDIUM RESOLUTION DISPLAY TO ASSESS DATA QUALITY BETWEEN RUNS
- POST FLIGHT GROUND CALIBRATION

GTRI
Georgia Tech Research Institute
Radar And Instrumentation Laboratory

DAILY QUICK LOOK PROCEDURES

- o CLOSE SIGNAL GENERATOR AND ABSOLUTE GROUND CALIBRATIONS - COMPARE PRE- AND POST-FLIGHT CALIBRATIONS
- o PROCESS SELECTED DATA SCENES INCLUDING THE AIRBORNE CALIBRATION ARRAY
- o CHECK CALIBRATION ARRAY FOR CALIBRATION CLOSE WITH GROUND CALIBRATION AND FOR RESOLUTION
- o ENTER ASSESSMENT OF DATA QUALITY OF SAMPLED RUNS INTO DATA BASE
- o PRODUCE 35 MM IMAGES OF SCENES

DAILY PRODUCTION PROCEDURES

- o Determine Scenes to be Processed from Priority List
- o Load Calibration File for a Set of Runs
- o Process Scenes
- o Dump Processed Scenes to CCT
- o Evaluate Scenes
- o Compute Statistics/Register With Ground Truth
- o Enter Summaries Into Data Base
- o Transcribe to Archival Storage Medium
- o Produce 35 mm Images of Scenes

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

DATA PROCESSING TRADE OFF

WITH THE PROPOSED SYSTEM A 1024 x 1024 SCENE CAN BE PROCESSED IN APPROXIMATELY ELEVEN MINUTES TO ACHIEVE A CALIBRATED, COMPLEX, HIGH RESOLUTION DATA SET.

THE TIME TO PROCESS ONE 1024 x 1024 SCENE IS THUS

11 MINUTES/SCENE x 4 POLARIZATIONS = 44 MINUTES.

THUS, THE MAXIMUM NUMBER OF 1024 x 1024 SCENES THAT CAN BE PROCESSED IN AN 8 HOUR DAY IS

480 MINUTES/DAY/44 MINUTES PER SCENE = 11 SCENES/DAY

THUS THE NUMBER OF SCENES THAT CAN BE PROCESSED IN THE TWO YEAR TEST PERIOD IS

104 WEEKS x 5 DAYS/WEEK x 11 SCENES/DAY = +5720 = 24.0 GIGA PIXALS

IN PRACTICE IT WOULD BE IMPOSSIBLE TO DO MORE THAN GLANCE AT SUCH A LARGE NUMBER OF SCENES. THUS, A COLOR DISPLAY WILL BE USED AS A BASIC ANALYSIS TOOL TO ASSESS THE SCENE INTEGRITY. IN THIS MANNER THE SCENES CAN BE PROCESSED AND VIEWED QUICKLY AND ONLY USEFUL SCENES SELECTED FOR PERMAMENT STORAGE AND LOGGING IN THE DATA BASE. THUS, VIRTUALLY ALL OF THE DATA COULD BE LOOKED AT AND A SUBSET SELECTED FOR ADDITIONAL ANALYSIS. AS AN OPTION, AN EXTRA ARRAY PROCESSOR COULD DOUBLE THE SCENES THAT COULD BE PROCESSED

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

C-131B SPECIFICATIONS

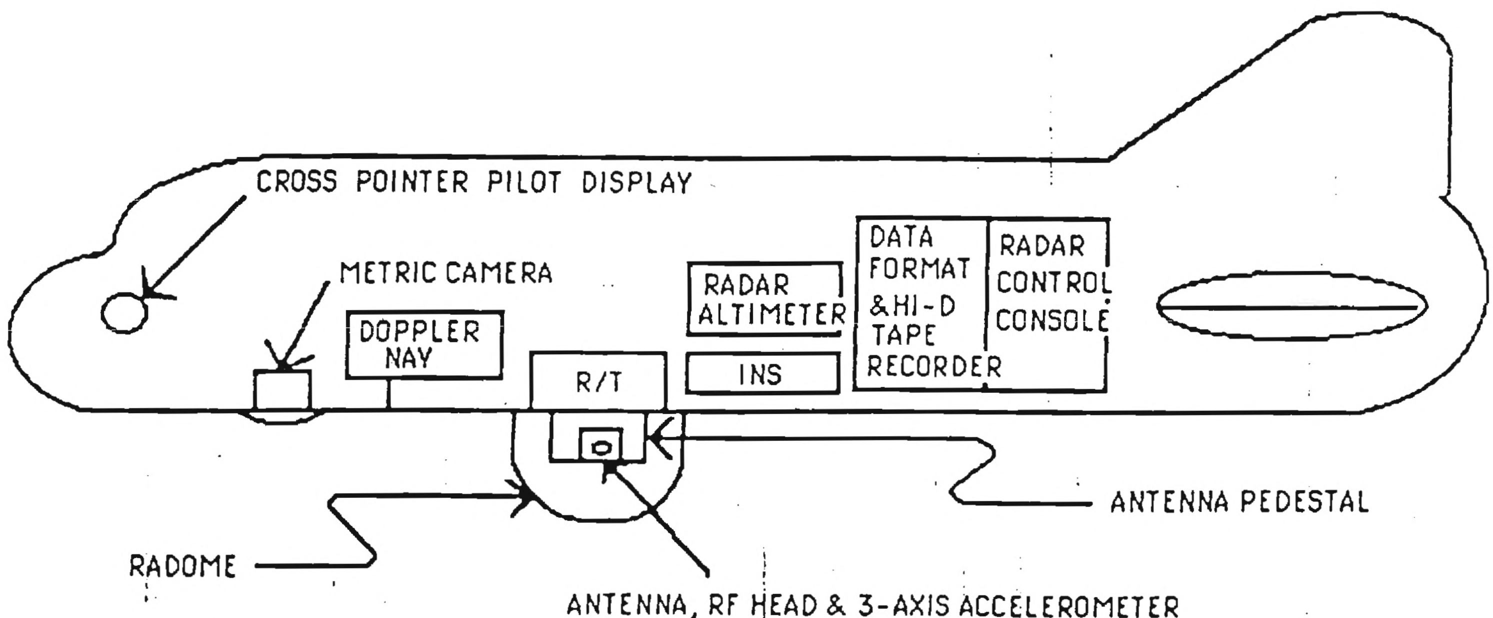
WING SPAN	106	FT.
LENGTH	79	FT.
HEIGHT	28	FT.
EMPTY WEIGHT	32,000	LBS.
GROSS WEIGHT	53,200	LBS.
MAXIMUM SPEED	295	KNOTS
CRUSING SPEED	220	KNOTS
INITIAL CLIMB	1,230	FT./MIN.
APPROXIMATE MAXIMUM TEST ALTITUDE	20,000	FT. MSL.
RANGE	1,300	NMI
RADOME POSITION	MUST BE ABLE TO ELEVATE ANTENNA 2° WITH UNOBSTRUCTED VIEW ON THE GROUND	

GTRI

Georgia Tech Research Institute

Radar And Instrumentation Laboratory

CONVAIR CV240 (T29) OR CONVAIR CV340 (C131)



Georgia Tech Research Institute
Radar And Instrumentation Laboratory

ESTIMATED COST SUMMARY TOTAL

ITEM	SALARY COSTS	MATERIALS	TRAVEL	TOTAL
Management	451,371	20,000	30,000	510,350
System Engineering	350,366	1,000		351,366
System Integration	365,636	26,400		392,036
Gymbal	244,467	330,000	4,000	578,467
Radome	61,395	100,000		161,395
Transmitter	100,915	10,000	1,609	112,525
RF, IF, Video, Data Acquisition, Radar Timing and Control	766,686	279,500	5,000	1,051,186
Pedestal	200,544	350,000		550,544
Data Acquisition - Nav System	116,511	20,000	5,000	141,511
Data Acquisition - R/T Digital	174,720	25,000		199,720
Data Acquisition - Inflight Processor	117,190	35,000		152,190
Data Acquisition - Interconnect	76,520			76,520
Data Acquisition - System Design	129,417		5,000	134,417
Data Acquisition - Data Analysis Van	300,991	80,000	5,000	385,991
			Total Preparation Cost	4,790,238

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

ESTIMATED COST SUMMARY TOTAL (CONTINUED)

	SALARY COSTS	MATERIALS	TRAVEL	TOTAL
FLIGHT TEST SUPPORT	642,867	100,000	120,000	862,867
QUICK LOOK ANALYSIS	287,553	50,000	80,000	417,553
PRODUCTION IMAGE PROCESSING	350,000	160,000	10,000	520,000
			TOTAL TEST/ANALYSIS COST (2 YEARS)	1,800,420
			COST PER SCENE (10,000 SCENES)	180
			TOTAL COST	6,590,658

OTHER ITEMS (ASSUMED GFE)	TOTAL
AIRPLANE	
INSTALLATION	558,427
TEST SUPPORT	2,164,520
INS & BEACON	200,000
HIGH DENSITY TAPE RECORDER	200,000
DOPPLER NAVIGATION SYSTEM	75,000
TOTAL GEF ITEMS	3,197,947

GTRI

Georgia Tech Research Institute

Radar And Instrumentation Laboratory

RECENT GTRI HARDWARE/MEASUREMENT PROGRAMS

SPONSOR	DESCRIPTION	START DATE	DURATION	ACTUAL AMOUNT	% OF ESTIMATE OVERUN/ (UNDERRUN)
ERADCOM	95 GHz Modulator	6/81	7 mos.	$99,000	0%
Gulf Interstate Corporation	Low Frequency Ground Penetration Radar	9/81	21 mos.	$500,000	0%
Teledyne Brown Corp.	Coherent Repeater	10/81	9 mos.	$290,000	0%
Westinghouse Corporation	Hi Res 35 GHz Radar Measurements	3/82	5 mos.	$410,000	0%
MICOM	SNOWMAN MMW Measurements	7/83	14 mos.	$2,400,000	0%
WSMR	AN/MPS-36 Radar Modification	9/82	24 mos.	$1,123,000	5%

Georgia Tech Research Institute
Radar And Instrumentation Laboratory

SENSOR SPECIFICATIONS

A. THE PROCESSED SIGNAL-TO-NOISE RATIO SHALL BE 60 dB AT 1.5 KM FOR A 10 dBSM TARGET. THE SIGNAL-TO-CLUTTER RATIO WILL BE 33 dB FOR -13 dB σ^0.

B. THE SPECIFIED RANGE AND CROSS-RANGE RESOLUTION SHALL BE OBTAINED IN BOTH THE STRIP MAP AND SPOTLIGHT SAR MODES.

C. ALL RADAR AND NAVIGATION SIGNALS WILL BE RECORDED IN RAW FORM TO SUPPORT SAR POST-PROCESSING.

D. THE ABSOLUTE SETTLING TIME OF THE SYNTHESIZER PROPOSED IS 1 μS WHICH FOR THE PRF RATE OF 32 KHz YIELDS A MAXIMUM RANGE OF 4.5 KM.

E. POLARIZATION ISOLATION SHALL BE 25 dB OVER THE MAIN BEAM GIVEN THE COMBINED EFFECTS OF ANTENNA AND RADOME.

SENSOR SPECIFICATION (CONTINUED)

F. THE STABILITIES REQUIRED FOR THE DESIRED SIDELOBE PERFORMANCE OVER THE 0.25 SECOND INTEGRATION PERIOD ARE SATISFIED.

G. THE CROSS-RANGE SWATH SHALL BE 150 M IN THE SPOTLIGHT MODE AND UP TO 1500 M IN THE STRIP MODE.

THE RANGE SWATH COVERAGE SHALL BE 100 M AT 50^0 AND 150 M AT 10^0 DEPRESSION ANGLE.

H. THE TARGET LOCATION ERROR SHALL NOT EXCEED 10 FT. RANGE AND CROSS RANGE.